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ABSTRACT

Part 1 of two publications reports a study which assessed the effectiveness of a college preservice instructional procedure in developing questioning skill in prospective teachers. Problems also investigated included transfer of this skill to the student teaching experience, and the relationship of selected personality factors (intelligence, sex, educational set, and personality type) to the development of this questioning skill. The study extended over three quarters and involved 42 preservice secondary teachers randomly assigned to four groups. Lessons observed were audiotaped and videotaped for analysis by three judges and the investigator. Resulting data were subjected to parametric statistical analyses with a .10 level of significance for hypotheses acceptance or rejection. Questioning appeared to be a skill that could be developed through instruction and practice. The development of questioning skill did not appear to be limited by intelligence, sex, personality type, or educational set. Part 2, included as a separate document, was used by the participants during the instructional procedure of the study. It provides information about questions and questioning techniques for stimulating good class discussions and critical thinking. (PR)

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A STUDY OF THE DEVELOPMENT OF THE SKILL OF EFFECTIVE QUESTIONING BY PROSPECTIVE SECONDARY SCHOOL SCIENCE TEACHERS

Patricia E. Blosser
Center for Science & Mathematics Education
The Ohio State University

September, 1970

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Patricia E. Blosser

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PREFACE

This publication is Part One of a two part final report of a study designed to assess the effectiveness of an instructional procedure aimed at developing skill in questioning, as a teaching technique, by prospective science teachers. Part Two of the final report consists of a handbook of effective questioning techniques, written by the investigator and used by the preservice teachers as a part of the instructional sequence.

A STUDY OF THE DEVELOPMENT OF THE SKILL OF EFFECTIVE QUESTIONING BY PROSPECTIVE SECONDARY SCHOOL SCIENCE TEACHERS

by

Patricia E. Blosser

The Ohio State University, 1970

Dr. Robert W. Howe, Adviser

ABSTRACT

The major problem investigated was to assess the effectiveness of an instructional procedure designed to develop skill in questioning, as a teaching technique, by prospective science teachers. Subproblems investigated were (a) to determine if skill developed during this instructional sequence would transfer to the student teaching experience and (b) to determine possible relationships of selected personality factors to the development of questioning skill.

The study extended over three quarters. A total of forty-two preservice secondary school science teachers were involved. The student teachers were given the Otis Quick-Scoring Mental Ability Test, Gamma Test, Form Em, to measure intelligence; the Myers-Briggs Type Indicator, Form E, to measure personality type; and the Educational Set Scale by Siegel and Siegel, to measure educational set.

During each quarter the subjects were randomly assigned to one of four groups: R_1, R_2, R_3, and R_4. A brief design of the study is as follows:

Group	Pretest	Treatment	Post-test
R_1	Yes	Teachers for instructional procedure	Yes
R_2	Yes	Student-evaluators for R_1	Yes
R_3	Yes	None	Yes
R_4	No	None	Yes

Randomly selected students from each of the four groups were observed during student teaching to determine if skill gained in the instructional sequence would transfer to the reality of student teaching and to determine the effects of time and student teaching on questioning skills. Lessons observed were audiotaped for subsequent analysis.

A panel of three judges analyzed the videotaped post-test lessons for types of questions asked. Audiotapes were analyzed by the investigator. Additional analyses were done to identify behaviors emphasized as a part of the instructional sequence. The data obtained from the lesson analyses and data obtained through the use of the written instruments were subjected to parametric statistical analyses to test the seven hypotheses of the study.

These hypotheses were (1) Skill in questioning as a teaching technique cannot be developed through practice and experiences involved in an instructional sequence; (2) There is no effect of treatment (teacher of a microclass, pupil in a microclass, member of a control group) on questioning behavior; (3) The skill developed during the instructional sequence will not transfer to the student teaching

experience in the public schools; (4) There is no relationship between intelligence and questioning behavior; (5) There is no relationship between sex and questioning behavior; (6) There is no relationship between educational set and questioning behavior; (7) There is no relationship between personality type and questioning behavior.

Three criterion variables were chosen to test the hypotheses. These were (1) asking Open Questions (those having a wide range of acceptable responses), (2) pausing to allow students time to think before responding, and (3) questioning in a manner designed to decrease the percentage of teacher talk during a lesson. The .10 level of significance was used for rejection or non-rejection of each hypothesis with respect to each of the three criterion variables.

Hypotheses one and two were rejected for the criterion variables of pausing and of decreasing the percentage of teacher talk. Hypotheses one and two could not be rejected for the variable of asking Open Questions. Hypotheses three through seven were not rejected, for any of the criterion variables.

The individuals involved in the study appeared representative of the population of preservice secondary school science teachers enrolled at The Ohio State University. Questioning appeared to be a skill that could be developed, through instruction and practice, by these individuals. The development of questioning skill did not appear to be limited by intelligence, sex, personality type, or educational set, in so far as this sample was concerned.

CHAPTER I

INTRODUCTION

The Problem

The major problem to be investigated for this study was to assess the effectiveness of an instructional procedure designed to develop skill in questioning, as a teaching technique, by prospective secondary school science teachers. Two subproblems were (1) to determine if the skill developed during the instructional sequence or procedure would transfer to the student teaching experience, and (2) to determine the possible relationship, if any, of such factors as educational set, personality type, intelligence, sex to an individual's questioning skill.

Introduction and Need for the Study

Interest in the area of questioning skills developed as a result of supervising a student teacher. This individual, who did not appear to be atypical of those involved in student teaching, seldom asked questions requiring more than factual recall to answer. Attempts to provide guidance so that she asked more than factual recall questions were relatively unsuccessful. A thoughtful analysis of problems student teachers face led to the hypothesis that student teachers need to do more than verbalize about specific teaching skills and techniques if they are to use these methods successfully in the classroom.

It has been stated that teachers dominate the verbal interaction in their classrooms. Flanders found that, in most classrooms, some individual is talking more than 60 per cent of the time and that, 70 per cent of the time, the speaker is the teacher (31:1). It has also been said that many teachers lecture a great deal when teaching because they know of no other way (3:55). It would appear that many teachers lack the skills and training necessary to stimulate thought-provoking discussion and to sustain and direct it.

Wallen and Travers (79:452-453) list six patterns of teacher behavior, classified by their origin: (1) patterns derived from teaching traditions, (2) patterns derived from social learnings in the teacher's background, (3) patterns derived from philosophical traditions, (4) patterns generated by the teacher's own needs, (5) patterns generated by conditions existing in the school and community, and (6) patterns derived from scientific research on learning.

If, as Wallen and Travers (79:453) imply, it is true that teachers teach in accordance with the pattern they observed when they were pupils rather than the pattern prescribed by teacher training institutions, this has implications for teacher education programs. Conscious effort must be spent in developing instructional sequences and providing opportunities for prospective teachers to be exposed to experiences so that they change their perceptions and develop models of desirable teaching methodology. Such experiences must be structured to provide a greater impact on the future behavior of preservice teachers than those of their past experiences as pupils.

Methods courses in science education provide prospective teachers with opportunities to work with materials and equipment. Such practicum courses seldom provide opportunities to develop instructional strategies. When the preservice teachers are involved in student teaching, they frequently lack the skills needed to promote the development of an inquiry approach by their students.

In science, many of the course content improvement projects emphasize the inquiry approach or "learning by discovery." Such an approach implies greater student involvement and initiative and less teacher-talk of the authoritarian and information-giving varieties. The teacher's role becomes that of helping students by posing reasonably structured problems that will lead to new discoveries for the students. The teacher must provide guidance in the techniques of data collection and organization (82:38-39).

Guiding, rather than lecturing, would imply a decrease in teacher-talk in science classrooms. Unfortunately, recent studies provide evidence that science teachers as well as those of other subjects dominate classroom talk. Balzer found the biology teachers he observed dominated the verbal activity in their classrooms approximately 61 per cent of the time (4:120). Snider, in his investigation of physics teachers, concluded that "much of physics teaching is 'telling'." (76:253). This would imply a predominance of teacher-talk in physics classrooms as he observed them.

Teachers need to structure the classroom situation so their pupils develop the ability to think for themselves and to question the validity of information. Simon and Boyer provide support for this assumption in their publication (75:11). They contend that if we assume that how a teacher says what he says has an impact on pupil learning as measured by interaction analysis systems concerned with the affective domain, it also appears reasonable to assume that how a teacher asks for data or gives it makes a difference. They think that a teacher who asks only for data recall should have a different impact on pupils than one who encourages pupils to process data in a variety of ways. A teacher who asks only data recall questions is prescribing a different thought process, according to Simon and Boyer, than is one who asks questions requiring pupils to process data. As knowledge increases, skills in how to acquire and to process data into useful information are rapidly becoming far more important than the skill of stockpiling data.

In order to promote the development of a skill in his pupils, the teacher must himself possess the skill to some degree and use it. Questioning is a teaching technique assumed to aid in the development of the skills of acquiring and processing data. Therefore, preservice teachers should be provided with opportunities, and guidance, to develop these skills so they may more effectively promote learning on the part of their pupils.

Questioning has been considered, by many, to be a skill that an individual entering the teaching profession does or does not possess. However, work on skill development in questioning has been done at Stanford University as a part of that institution's teacher education program (11). Researchers at Stanford are interested in determining the psychological effectiveness of conditions in which questioning skill development takes place. They have not, however, attempted to investigate the relationship of certain individual factors to questioning skill. Nor have these investigators attempted to conduct follow-up studies of their teacher interns to investigate if the questioning skill developed during the training sessions involving microteaching is transferred to the teacher's behavior when he works with a large class for an extended period of time.

Questioning has long been accepted as an effective teaching technique. This acceptance appears to have been based largely on intuitive feelings rather than upon research data. Early studies of questioning have concentrated upon describing questioning rather than upon improving it. One of the earliest studies of the use of questions was that of Stevens in 1912 (77). She conducted a four year study, observing teachers in grades seven through twelve in both public and private schools to investigate their questioning practices. Stevens felt that questions could stimulate mental activity or could defeat the psychological aim of the lesson (77:5).

In her 100 random observations of teachers categorized as the best in their schools (77:8), Stevens found questioning activity ranging from no questions per period (a lecture was being given) to 122 questions in one period in one class. On the average, teachers asked two to four questions per minute (77:16). Stevens grouped the teachers into those asking more than ninety questions per lesson and those asking fewer. She did not find what she termed good questions in either group. Stevens attributed this lack to five possible causes: (1) lack of clearly defined purposes of instruction, (2) failure to appreciate the function of the question as a medium of instruction, (3) dominance of the textbook, (4) the feeling of indifference to the methods of recitation in colleges and training schools for teachers, and (5) the almost total neglect of supervision of instruction in secondary schools (77:71).

If the kinds of thinking that students engage in depends upon the kinds of questions teachers ask (38:118-133), then teachers need to be provided with opportunities to acquire skill in asking questions. Science in the secondary schools involves classroom discussions as well as laboratory investigations and field trips. Preservice teachers should be enabled to develop some initial amount of skill in questioning as a part of their preparation program. At this time guidance and diagnosis should be made available. Beginning teachers should not have to develop questioning skill, by trial and error, during their first years of teaching.

If one accepts the assumptions that the prime concern of a teacher education program should be with its end product: the teacher, and that one objective of teacher education programs is to produce an effective, competent teacher who can help children learn, it would seem that an exploratory study of the development of the skill of effective questioning by preservice secondary school science teachers would be a worthwhile contribution to the profession.

Definition of Terms

The terms employed in this study are defined at this point to provide information relative to the problem detailed in the preceding pages and to the hypotheses stated in the succeeding pages of this chapter.

1. Category System: a method of classifying questions relative to the type of cognitive process the question is designed to stimulate in the pupil.

2. Closed Question: one for which there is a limited range of acceptable responses.

3. Cognitive Processes: categories of thinking, identified in hierarchical complexity, as in Bloom's *Taxonomy of Educational Objectives* (6) or in Guilford's "Structure of Intellect" model (40), or covert mental operations such as differentiation, identification of common properties, extrapolation, etc.

4. Cognitive Style: the pattern of behavior that characterizes an individual's customary pattern of thinking and acting.

5. Educational Set: a type of cognitive style which is presumed to determine the specific kinds of content the learner tends to extrapolate from his various educational experiences. It comprises a continuum with extremes of predispositions to learn factual content or conceptual content (73).

6. Higher-order Questions: questions designed to stimulate thinking operations above the levels of cognition and memory.

7. Instructional Sequence: the structured experiences to which the prospective secondary school science teacher will be exposed and the activities in which he will be engaged as he learns to use the category system and then uses it to develop some degree of facility in questioning.

8. Microteaching: a teacher education technique which allows an individual to teach a carefully planned lesson, using clearly defined teaching techniques or skills, in a planned series of short encounters with a small group of students, either of the age group he plans to teach in the future or of peers.

9. Open Question: one for which there is a wide range of acceptable responses.

10. Pausing Technique: waiting for at least three seconds before demanding a response to any question considered to be above the level of cognitive-memory in the Question Category System.

11. Personality type: a distinctive and relatively permanent characteristic aspect of the behavior of an individual, as exemplified by the traits of intraversion-extroversion, intuition-perception, etc. (61).

12. Prospective Science Teacher: a preservice teacher, enrolled in the College of Education, who is planning to teach science in some secondary school system upon graduation from college.

13. Question Category System: a system, designed by the investigator of this study, for classifying questions asked by teachers during science lessons.

Hypotheses

1. Skill in questioning as a teaching technique cannot be developed through practice and experiences involved in an instructional sequence. (Skill in questioning is to be exemplified by the teaching strategies of asking open questions as well as closed questions, use of the pausing technique, and asking questions in a manner designed to decrease teacher-talk.)

2. There is no effect of treatment (teacher of a microclass, pupil in a microclass, member of a control group) on questioning behavior of a preservice teacher.

3. The skill developed during the instructional sequence will not transfer to the student teaching experience in the public schools.

4. There is no relationship between intelligence and questioning ability.

5. There is no relationship between sex and questioning ability.

6. There is no relationship between educational set and questioning ability.

7. There is no relationship between personality type and questioning ability.

Assumptions

1. The verbal behavior of the teacher in the classroom is important as a means of transmitting information and promoting learning.

2. The kinds of questions science teachers ask influence the outcomes of science teaching.

3. Questioning is a skill that can be developed, to a degree limited by individual differences, through practice and instruction.

4. A category system for classifying a teacher's questions can be developed.

5. An instructional sequence can be devised that will enable preservice teachers to develop skill in questioning.

6. The instruments chosen will assess the variables for the purposes for which they are being used in the study.

7. The three weeks allotted for the instructional sequence is an adequate amount of time for significant improvement of some questioning skills.

Limitations

1. The category system is descriptive and diagnostic and not ideal or prescriptive.

2. The presence of an observer, during the student teaching experience, may have influenced the questioning behavior of the particular student teacher being observed.

3. The group being taught influenced the student teacher's questioning patterns.

4. The lesson (content, purpose) influenced the types of questions the student teacher asked.

5. The judges' competence in using the Question Category System was limited by their understanding of this system and its guidelines.

6. The three weeks allotted for the instructional sequence may not have allowed adequate time for development of the questioning strategies involved in the study and their transfer to the student teaching experience.

Delimitations

1. The study was limited to individuals enrolled in Education 587.27, Student Teaching in Secondary Schools: Science, in the College of Education, The Ohio State University, during four quarters: Winter, 1968-1969; Spring, 1968-1969; Autumn, 1969-1970; Winter, 1969-1970.

2. Data were collected for only three of the four quarters, with Winter Quarter, 1968-1969, being used for the purposes of a pilot study, thus limiting the number of individuals about whom data were collected.

3. Only the verbal questioning of the student teachers involved in the study was analyzed. The nonverbal components were not considered as a part of this study.

4. The analysis of questioning techniques was limited to fifteen minute segments of time, both in the microteaching lessons and in the taped lessons from the public school science classrooms.

5. The classification of questions was limited by the judges' competence in interpreting and applying the Question Category System.

Procedure

During each of the three quarters of the study in which data were collected, the students enrolled in Education 587.27 were randomly assigned to one of four groups: R_1, R_2, R_3, and R_4. Groups R_1, R_2, and R_3 were pretested, using a videotaped ten to fifteen minute microteaching discussion lesson in science. All four groups were post-tested in a similar microteaching situation, also videotaped. Group R_1 participated in the instructional sequence as teachers, conducting three more microteaching lessons of the teach-reteach variety which were also videotaped. Group R_2 served as students and evaluators for R_1 during the instructional sequence. Groups R_3 and R_4 served as control groups.

A brief design of part one of the study is as follows:

Group	Pretest	Treatment	Post-test
R_1	Yes	Teacher in instructional sequence	Yes
R_2	Yes	Student-evaluators for R_1	Yes
R_3	Yes	None	Yes
R_4	No	None	Yes

In part two of the study, during each data-gathering quarter, randomly selected students from each of the four randomly assorted groups were observed during their student teaching to determine if skill gained in the instructional sequence would transfer to the public school classroom and to determine the effects of time and student teaching experience on questioning skills. These students were observed and audiotaped three times during student teaching: the first week they were given full responsibility for their classes, during the middle of student teaching, and the final week of student teaching.

The videotapes of the pre- and post-test microteaching lessons and the audiotapes of the classroom lessons recorded during student teaching were analyzed for the types of questions asked as well as for evidence of behaviors emphasized as a part of the instructional sequence. This analysis of questions was done by a panel of three judges who were senior faculty members of the Faculty of Science and Mathematics Education.

Data were coded and processed with the IBM 360 computer, using programs from the Biomedical (BMD) Computer Program series (Dixon, 27): 01D, simple data description; 02D, correlation with transgeneration; 02R, stepwise regression; 01V, analysis of variance for one-way design; 02V, analysis of variance for factorial design. (Possible output from each program is listed in Appendix A.) Levels of significance are reported at the .10 level.

CHAPTER II

REVIEW OF RELATED LITERATURE

INTRODUCTION

Educators have advocated the use of the question as a teaching device for many years. Textbooks of general methods of teaching, written in the late nineteenth century and early decades of this century, contain descriptions of the use of questions in teaching [Burton (10), Douglas (28), Lancelot (54), Strayer (78), White (80)]. In 1924 Odell (62) wrote "The Use of the Question in the Classroom," a publication filled with descriptive advice designed to help teachers improve their questioning practices.

A decrease in emphasis on questioning is apparent in "methods" textbooks published in the 1940's and 1950's. Some authors did devote portions of a chapter to questioning skills [Risk (67), Schorling (70)]. One general methods book, the third edition of which was published in 1962, contains a chapter entitled "Improvement in the Use of Questions," (9:436-448) but this situation is an exception rather than the rule.

This chapter will not contain a discussion of literature devoted to the functions, characteristics, and types of questions that teachers may or do ask. Information of this sort may be gained by reading the references contained in the bibliography or by pursuing references in the bibliographies of dissertations written by Cunningham (24), Moyer (60), or Schreiber (71), to cite some representative examples.

The materials reviewed in this chapter consist primarily of studies of questions teachers ask in classroom situations and of studies concerning attempts to help preservice and/or inservice teachers improve their questioning techniques.

Literature concerned with microteaching, used in the instructional sequence in this investigation, will be reviewed as a part of Chapter III.

Question Classification Systems

A number of reports and studies were concerned with the development of systems for use in classifying questions. Some of these reports were limited to the description of the system developed. Others contained not only a description of the classification system but also a report of the data obtained through the use of the system.

Several systems [Amidon (2), Carner (14), Frankel (34), Gallagher and Aschner (38), Shrable and Minnis (72), Simon and Boyer (75)] are content-free and may be used with any subject. The primary intent of the developers appears to have been to provide a vehicle for teachers to use in analyzing their questioning habits and to improve their technique.

The six levels of thinking found in Bloom's Taxonomy of Educational Objectives (6:201-207) form the basis for several question classification systems [Clegg, Farley and Curran (2), Los Angeles City

Schools (55)]. Still other systems [Davis and Tinsley (25), Davis et al. (26), Farley (29), Morse and Davis (59)] use Sander's modification of Bloom's Taxonomy.

Three category systems [Amidon (2), Hunter (42), Morse and Davis (59)] were concerned with student responses as well as teacher questions.

Some classification systems were concerned not only with the types of thinking demanded by the teacher's questions but also with the flow of classroom interaction. Amidon's system (2) used an expansion of Flander's Interaction Analysis system for analysis of the verbal interaction and also used the four levels of cognitive production contained in the Gallagher-Aschner system for question classification. Hunter (41) modified the revised Verbal Interaction Category System (VICS) and combined it with the four categories of the Gallagher-Aschner system.

In summary, the representative question category systems described in this section are primarily concerned with the cognitive aspects of questions and teachers' questioning behavior. Although a few systems include student response categories, the majority are concerned only with the questions asked. A commonly-held assumption appears to be that questions are asked to elicit thinking on the part of students and that the type of question asked is indicative of the level of response that will result.

Not all studies found in reviewing the literature were concerned with the classification of oral questions. Any of the classification systems just described could also be used to analyze questions found in written materials such as textbooks, workbooks, laboratory guides, etc. Studies of written questions will not be described in this chapter but are listed in the bibliography.

STUDIES OF CLASSROOM QUESTIONING PRACTICES

If stimulating thinking is a teacher's primary purpose in questioning, he needs to consider whether this objective is achieved. Studies of classroom questioning appear to be of two major kinds: those reporting what takes place when a lesson is in progress and those concerning the improvement of questioning techniques.

The studies reported in the following pages have been placed in two major divisions: science and subject areas other than science. Within each of these two divisions, the studies are grouped as descriptive or experimental. The number of studies identified was not sufficiently large to permit a more detailed system of grouping into elementary and secondary school levels, preservice teachers vs. inservice teachers, etc. Some investigators involved both preservice and inservice teachers in their sample. Others used different educational levels and/or involved a variety of subject matter areas. Those studies in which science classes were included in a sample containing English and/or social studies classes will be described in the section immediately following.

Classrooms Other than Science: Descriptive Studies

One of the earliest studies of classroom questioning is that reported by Stevens (77) and described in Chapter I. Stevens found that the number of questions asked ranged from 9 to 122 per class, with teachers asking from two to four questions per minute (77:11-16). She inferred that if so many questions were asked so rapidly, there was little opportunity for students to do more than recall information and make superficial judgments (77:22). Stevens estimated that she could find, in a total of 2,000 questions, approximately 200 to 300 questions designed to elicit reflective thought (77:84). She advocated that teachers plan about six to eight thought-provoking questions per lesson by which they hoped to have their students make association of elements, to discriminate, to weigh values (77:84).

Corey (22) also studied classroom questioning practices. After observing six classes in a laboratory high school for one year, Corey compiled a total of 39,000 questions, fewer than 4,000 of which were asked by students. The total number of questions varied with the class being considered but, in general, there were about eight teacher questions for every pupil question (22:745). Approximately 38 per cent of the teachers' questions were not answered by students. Either there was no response or the teacher proceeded to answer his own question (22:748).

Corey (21) analyzed thirty-six class hours of dialogue and found 1,260 teacher questions and 114 student questions. Approximately 500 of the teacher questions in this sample were not answered by pupils (21:372). A panel of judges analyzed the questions and reported that only one teacher question of every four appeared to require a thoughtful answer. The remainder of the questions involved recitation of memorized names, dates, or principles (21:372).

Floyd (32) analyzed the oral questioning activity in forty primary level classrooms in Colorado elementary schools, visiting thirty classrooms for one hour each and spending a day in each of ten more classrooms. Floyd found, from the thirty hour-long visits, teachers asked a total of 6,259 questions, 42 per cent of which were concerned with specific facts. Memory questions constituted 53.5 per cent of the total. Floyd found that teachers dominated oral classroom activity, asking questions that generally were of a low quality (memory questions), often acting as cross examiners in that they demanded short factual answers to short factual questions.

Adams (1) conducted an investigation to compare questioning practices in English and in social studies classes with those Stevens reported in her 1912 study. He collected data on seventeen English teachers and fifteen social studies teachers in grades seven, eight, eleven, and twelve. Adams found significantly fewer memory questions than in the 1912 study. He also found statistically significant differences in question categories used in English and in social studies classes as well as significant differences between teachers within content areas at different grade levels and different ability levels (1:2809-2810).

Clements (18,19) analyzed discussions that took place in art classes. In comparing questioning activities in grades one and seven and in college art classes, Clements found the length of student answers did not vary much from level to level. One-half of the questions received answers of one second or less duration. One-fourth of the questions were not answered. Teachers asked about one question per minute and did not appear to pause to give their pupils a chance to think.

The studies cited involved inservice teachers. Davis and Tinsley (25) worked with forty-four student teachers in secondary school social studies classes. Using a nine category system for classifying questions (Bloom-Sanders seven categories plus "affectivity" and "procedure"), they found both student teachers and their pupils asked more memory questions than all other question categories combined (25:23). The next largest numbers of questions were those of "interpretation" and "translation," followed by "procedural" questions. Davis and Tinsley concluded that more deliberate attention needs to be given to different cognitive objectives in social studies classrooms and that preservice and inservice education programs need to emphasize the skills of classroom questioning (25:25).

Pate and Bremer (66) contacted 190 teachers in grades one through six to investigate why teachers ask questions. They found that 68 per cent of the respondents to their questionnaire asked questions to check on the effectiveness of their teaching: to determine what their pupils had learned. The next four reasons listed were: to diagnose pupils' learning difficulties (54 per cent), to check pupils' ability to recall facts (47 per cent), to meet individual needs (17 per cent), and to determine grades (16 per cent). Pate and Bremer concluded (1) teachers use questions for a number of purposes, (2) some teachers apparently have not given much thought to the purposes questions can serve, (3) most ask questions requiring short answers and do not give their pupils practice in using the skills of generalizing and inferring (66:419).

No valid generalizations can be made on the basis of the small number of studies contained in this section. If the group of studies were to be summarized, several points seem to be true for the majority cited. Teachers dominate the oral activity of the classrooms, asking a large number of questions the bulk of which call for little more than factual-recall thinking operations on the part of the pupil responding. In most of the research, the investigators did not attempt to relate the questioning activity to such things as content area (as compared with another subject), student achievement, or teacher characteristics.

Classrooms Other than Science: Experimental Studies

Researchers have also been interested in devising methods for improving teachers' questioning skills. Some have worked with inservice teachers. Others have concentrated their efforts in preservice education. Still others have involved both preservice teachers and their cooperating teachers.

Clegg, Farley, and Curran (17) attempted to design a procedure for training teachers to recognize the different levels of cognitive behavior and to develop classroom learning procedures which include all levels of cognitive behavior. Six student teachers of grades one through six and their cooperating teachers were involved in the study. The student teachers had studied Bloom's Taxonomy in a social studies methods course prior to student teaching.

Both groups (student teachers, cooperating teachers) were pretested at the beginning of the study and were post-tested eight weeks later. (No information concerning training for either group was reported.) Upon analyzing the data obtained, the investigators could find no significant differences in the level of discrimination of classroom questions by cooperating teachers and by student teachers (17:11) and inferred that the instrument used was not sufficiently sensitive for the purpose intended. Clegg and his coworkers found that student teachers asked a wide range of questions, with only 26.77 per cent of the total being at the knowledge level. Levels one and two did, however, account for 54 per cent of the total questions asked.

Farley (29) worked with student teachers of grades one through three to improve the level of questions they asked. The student teachers were divided into two groups. The experimental group received instruction in applying Sanders' modification of Bloom's Taxonomy to their teaching procedures. The control group spent an equal period of time working with Flanders' Interaction Analysis.

The student teachers in the experimental group listened to recordings of their teaching and evaluated these class sessions, using the modified Taxonomy. The six cooperating teachers and three additional raters analyzed tape recordings from the third, fifth and seventh weeks of teaching. Using these data, Farley found student teachers in the experimental group asked a larger percentage of above-memory questions. The level of questioning seldom went above the "interpretation" category, however (29:86). The student teachers did not exhibit an increase in questioning skill over the total eight week period. Achievement increased during the first three weeks and, apparently, repetition took place during the time remaining (29:84).

An additional paper issued by Farley and Clegg (30) contains a report that training in the use of the Taxonomy did make a difference in the cognitive level of the questions student teachers asked but that the level of the questions seldom rose above that of "interpretation." Farley and Clegg conclude that social studies goals calling for stimulating higher levels of thinking are not being achieved through the use of questioning.

Three other studies [Houston (41), Parsons & Shaftel (65), Schreiber (71)] involved efforts to improve questioning techniques of inservice social studies teachers. Houston (41) used individual and group conferences and self-evaluation techniques in working with eleven teachers in two junior high schools. He found, comparing the first and last lessons recorded, that teachers had made improvement in their questioning behavior.

Parsons and Shaftel (65) reported a short study involving a group of teachers of the upper elementary grades. The teachers were videotaped during three lessons. After the first taping, the teachers viewed their tapes, tallied the number of questions they asked, and analyzed the thinking each question demanded. They found 43 per cent of their questions were rhetorical, 45 per cent information-recall, 9 per cent leading (contained the answer or a definite clue), and 3 per cent probing (asked students to investigate relationships, to broaden their thinking). One week later, the second taping took place. Analysis of these lessons resulted in 28 per cent rhetorical questions, 37 per cent information-recall, 26 per cent leading, and 9 per cent probing. Analysis of a third taping found still no increase in the number of probing questions teachers used. The investigators concluded that teachers were able to exhibit some improvement in their questioning patterns through self-analysis (65:123-166).

Schreiber (71) worked with inservice elementary school teachers, using social studies subject matter, in an attempt to answer three questions: (1) what is the prevalent type of question asked in social studies lessons in self-contained fifth grade classrooms, (2) do the types of questions vary from one lesson to another, and (3) will an instructional program to change teachers' question-asking practices have an effect?

Schreiber devised an instructional program consisting of four one hour sessions, held at the end of a school day on subsequent days of the week. During these sessions the teachers were provided with guidelines for effective questioning and worked with social studies materials, formulating and analyzing questions. The teachers devised their own classification systems for questions.

The teachers were observed and taped, by the investigator, during three types of lessons: introductory, developmental, and review. Each type of lesson was observed both before and after the instructional program. A panel of judges analyzed the questions teachers asked, using a five item question classification scale Schreiber devised (71:153-155).

Schreiber found (1) the most prevalent type of question asked was that of factual recall, (2) teachers' questions did vary from one lesson to another, with this variation being due to other than chance in most instances, and (3) instruction in questioning did make a difference in teachers' classroom performances: the percentage of factual recall questions decreased. Schreiber also found that the type of lesson being taught influenced the types of questions the teacher asked (71:157-161).

Cross (23) attempted to develop an instructional program to enable English teachers to improve discussion skills, particularly those of question-asking. She conducted a pilot study, working with intern teachers, to devise the program. [illegible]s's study consisted of the exposition of the development of this instructional program. The program and materials apparently did not undergo further evaluation and modification before the dissertation was written.

Cross found that interns, in their class discussions, were so intent on asking all of the high-level questions they had preplanned that they frequently did not wait for maximum student response to a question. Nor did they listen carefully to, and use, student responses. Cross concluded that interns could preplan a variety of acceptable high-level questions but were unable to execute these questions in the classroom discussion (23:44). In conferences with the interns, Cross discovered that the interns thought they were being encouraged to drop the use of fact-recall questions from their discussions. Cross suggested that teachers be provided with opportunities to use both kinds of questions (fact-recall, high-level) in teaching before being asked to concentrate on using high-level questions.

Personnel at the Far West Laboratory for Educational Research and Development are also involved in helping teachers improve questioning behavior. A series of minicourses, each emphasizing different teaching skills, is being developed. Minicourse One, "Effective Questioning in a Classroom Discussion," was designed for use by inservice elementary teachers. It was field-tested, however, with preservice elementary school teachers at three different colleges (Kallenbach, 46). Students on all three campuses were involved in student teaching when they participated in the field-testing program.

When the three groups of students were compared, the differences favored the student teachers who had completed the minicourse. These individuals made significantly greater improvement in two scores: repeating pupil answers (goal: not to do this) and percentage of teacher talk (goal: to decrease this) (46:9-10).

Information obtained from interviews and questionnaire data provided a basis for the inference that student teachers had too many demands on their time to allow for adequate use of the minicourse. They were unable to complete some of the required activities. Kallenbach suggested that, in a preservice setting, the minicourse should be offered on a two or three days per week basis rather than as a daily assignment (46:10). He urged that the work be continued because, despite the problems that arose, significant changes did occur in the methods of questioning and conducting discussion lessons that were used by the participating student teachers.

The research studies cited here, although few in number, provide an indication that programs can be developed for improving questioning behavior. The amount of success achieved appears to depend in part upon the teachers' perceptions of the situation as well as upon the methodology the instructional programs involve. Again, as in the descriptive studies, the emphasis was upon increasing the variety of questions teachers ask and upon raising the cognitive level of the questions used. Apparently attempts to correlate improvement, or lack of it, in questioning with such additional factors as student achievement, teacher characteristics, etc., were considered to be beyond the scope of the studies as they were designed.

Questioning in Science Classrooms: Descriptive Studies

Several individuals interested in classroom questioning practices limited their investigations to science lessons or science classes. Moyer (60) conducted an exploratory study of the instructional processes in selected elementary schools. He observed and tape recorded fourteen science lessons, concentrating on the questions identified in those lessons.

Moyer considered six items in his analysis of questions: (1) type, (2) structural form, (3) function, (4) relationship between structure and function, (5) teacher development and utilization of questions, and

(6) teacher awareness of the questioning process (60:1). The teachers involved in the study were informed of Moyer's objectives. Each observation was followed by a relatively unstructured interview (also tape recorded) with the teacher.

Moyer compiled 2,500 questions from the fourteen science lessons. All questions were examined within the context of the lesson and were classified into categories on the basis of function determined by the response elicited. Moyer developed thirty-seven functional categories which he grouped into nine larger divisions. He found that none of the 2,500 questions recorded stimulated an evaluative response from the pupils involved.

Moyer also found that two-fifths of all questions required pupils to respond in ways requiring little or no mental effort. When categories were combined, 71 per cent of the questions required a minimum of thinking. Not all of the questions received responses (study average was 62 per cent response), so the percentage of questions eliciting higher thought processes was reduced still further (60:214).

The measure of questioning effectiveness, Moyer decided, seems to depend on the importance of the function, percentage of responses, and quality of content. He noted that many inadequate responses were accepted by teachers and concluded that teachers are not prepared to develop and effectively utilize the questioning process.

Kleinman (47,48) also conducted an exploratory study of questioning practices to (1) ascertain the kinds of questions general science teachers ask, (2) investigate the relationship, if any, between the kinds of questions general science teachers ask and pupil and teacher behaviors, and (3) determine whether the kinds of questions general science teachers ask influence pupils' understanding of science.

Kleinman conducted a pilot study to test an observational instrument for classifying questions and teacher and pupil behaviors. Upon completion of the pilot study, she observed twenty-three different general science teachers for one period each and selected, on the basis of questions heard during these single observations, two groups of three teachers each for further observation. The "high" group consisted of three teachers who asked nine or more critical thinking questions during the lesson. The "low" group was composed of three teachers who asked no critical thinking questions as defined by Kleinman's category system.

Each of these teachers was observed four times. Kleinman found (1) teachers in the "high" group asked 478 questions, and (2) the "high" group of teachers asked significantly fewer rhetorical and factual questions and twice as many neutral questions as did those in the "low" group. Checking her observation records, Kleinman found teachers in the "high" group tended to give directions or implied commands in an interrogative form, accounting for this variation (48:310).

Kleinman (48) grouped questions as higher type and lower type. Higher type questions were defined as those calling for comparisons, inferences, and supporting of conclusions. Lower type questions required simple recall and memorization-limiting responses. Using these definitions, she found that teachers in the "high" group asked 189 higher type questions and 182 lower type questions. Teachers in the "low" group asked 54 higher type questions and 423 lower type questions. When Kleinman combined neutral, rhetorical and factual questions into "lower type" and clarifying, associative, and critical thinking questions as "higher type" the difference between the two groups of teachers was significant at the .01 level of confidence (47:102). Kleinman inferred, from this, that teachers in the "low" group were limiting student responses rather than stimulating thinking.

In summary, Kleinman found (1) the kinds of questions teachers ask are fairly stable for each teacher, (2) teachers who ask more critical thinking questions tend to ask fewer questions per minute, (3) teachers who ask more critical thinking questions also ask more neutral, clarifying, and associative questions and fewer rhetorical or factual questions to a degree significant at the 0.01 level of confidence for each category of questions, and (4) only one value question was asked in all thirty-five observations (47:99-107, 48:315-316).

A group of studies, carried out at different institutions, was concerned with elementary school teachers and one of the newer elementary school science programs. A survey of these studies resulted in additional information of questioning practices in science lessons [Bruce (8), Kondo (49), Moon (58), Wilson (81)]. All of the investigators worked with inservice elementary school teachers and the Science Curriculum Improvement Study materials.

Wilson (81) analyzed the teaching procedures of thirty elementary teachers, fifteen of whom were using the SCIS materials. Two observations of each class were made, one week apart at the same time of the school day. The verbal interaction was tape recorded. When Wilson categorized the questions asked, he found that recognition and recall questions were asked a significantly larger proportion of times by teachers using the more traditional elementary school science materials. The SCIS teachers asked a significantly larger proportion of analysis and synthesis questions as well as more skill type questions. In addition, SCIS teachers asked more questions than did teachers using the traditional materials (81:67-69).

Bruce (8) examined the extent of the relationship among selected teacher personality factors, science process skills, attitude toward teacher-pupil relationship, and the verbal characteristics of question asking. Thirty-three elementary school teachers were involved in the study, fifteen of whom were observed and tape recorded prior to their participation in the three week workshop designed to acquaint them with SCIS materials. A total of 220 science lessons was taped and the questions identified in these lessons were analyzed, using Bloom's Taxonomy. Bruce found a significant difference in the level of questions asked before and during formal involvement in the SCIS program. The number of high level questions increased, with a significantly greater proportion being analysis questions.

Moon (58) worked with thirty-two elementary school teachers and attempted to analyze selected examples of verbal behavior patterns in primary grade classrooms during science activities. Sixteen teachers used SCIS materials; the other sixteen served as a control group. Moon tape recorded the science lessons for analysis involving the use of

Flanders' Interaction Analysis system, the Science Teaching Observational Instrument, and the Science Process Test for Elementary School Teachers. Moon found, after the SCIS teachers had participated in a workshop designed to involve them in the use of SCIS materials, question preferences changed from low order questions to high level questions.

Kondo (49) studied the classroom behavior of SCIS teachers to determine if a possible relationship exists between questioning behavior and different types of SCIS lessons. In SCIS "invention lessons" teachers introduce a concept to children. In "discovery lessons" children apply a concept to new situations. Kondo tape recorded four lessons (two invention, two discovery) of four first grade teachers in the same school. He found that the way the lesson was approached (teacher demonstration or children handling materials) had a greater influence on the types of questions asked by the teacher than the type of lesson (invention, discovery) *per se*. The differences of question types and frequency among individual teachers were more striking than the average across lessons. Kondo also found one type of question tended to be followed by questions of the same type to a greater extent than would be indicated by the over-all distribution of questions (49:9).

Hunter (43) analyzed the verbal behavior of twenty-two first grade teachers as they taught science. Eleven of these teachers had participated in an inservice education program designed to acquaint them with one of six of the newer elementary school science programs. The other eleven, the control group, had no special training in elementary school science programs. The verbal behavior of the twenty-two teachers was analyzed, using the Revised VICS-Science observation system. Hunter found there was no significant difference in the amount of questioning behavior of the two groups. She had hypothesized that the experimental group would ask more divergent and evaluative questions.

Hunter found that neither group used these categories. In both groups, only .4 per cent of all questions were evaluative and .4 per cent divergent. About 95 per cent of all questions were of the cognitive memory type (97.2 per cent for the control group, 93.2 per cent for the experimental group) (43:41). If a teacher asked a broad question which was not immediately answered, she tended to delimit it until it became one of the cognitive memory type.

When the verbal behavior of the two groups was compared, the teachers in the experimental group who had received inservice education did not vary from those in the control group. Those who had participated in the inservice program did talk significantly less than the control group but the verbal patterns were not different. Hunter inferred that, although some of the teachers were using the newer science materials, divergent and evaluative thinking activities were not taking place if these activities were to be stimulated by teacher questions. Changes in curriculum content will not necessarily result in changing teacher behavior, according to Hunter's study (42:42).

If these several studies are typical of the verbal interaction taking place in most science classrooms, the majority of science teachers appears to be functioning at the level of cognitive-memory thinking operations in their question asking behavior. This would appear to be true at both the elementary and secondary school levels. Although there appears to be much concern for the kinds of questions teachers ask and the relationship of those questions to student learning, little, if anything, was done as a part of these studies to prepare teachers to use questions effectively. If teachers' questioning skills did improve, this improvement was generally a side-benefit from the main focus of the study reported. Again, as in the studies of other subject areas, the investigations were concerned primarily with the cognitive levels of questions.

Questioning in Science Classrooms: Experimental Studies

A few attempts have been made to help science teachers improve their questioning techniques [Cunningham (24), Johnson (44), Konetski (50), Koran (51), Masla (57), Rowe (68)]. Both preservice and inservice teachers have been involved in these studies.

Three investigators [Cunningham (24), Koran (51), Masla (57)] worked with preservice elementary school teachers enrolled in science methods courses. Cunningham (24) attempted to change the question-phrasing practices so that prospective elementary school teachers would ask a greater proportion of high level questions of the divergent thinking variety, as defined by Gallagher and Aschner. He worked with forty students enrolled in two science education methods courses. Students, who had been pretested, were post-tested after seven periods of instruction on question-phrasing. Their questions were analyzed by a panel of seven judges. Cunningham found a significant decrease in the number of cognitive-memory questions from pre- to post-test as well as a significant increase in the number of divergent thinking questions. There were no significant changes in the number of convergent thinking questions asked. Nor was any change in the number of evaluative questions reported.

Masla (57), working with seventy-six preservice elementary school teachers, studied the effect of instruction in an interaction analysis system on the verbal inquiry patterns of these individuals as they taught lessons in science. The seventy-six students were pretested with the Elementary Teacher's Science Inventory (ETSI) to determine their competency in science processes. The students were divided into high and low competency groups on the basis of their ranked scores and were then randomly assigned by rank to either an experimental group or a control group. The experimental group received intensive instruction in interaction analysis.

Upon completion of the instruction, forty students from the total group were randomly selected to teach science lessons to elementary school children who had volunteered to participate in the study. Masla recorded these lessons and analyzed the verbal interaction. He found a significant effect attributable to differences between the means of the question ratios of the two groups, with the direction of significance in favor of the experimental group. The experimental group means indicated a significantly greater proportion of open-ended questions. The level of competency in science processes did not appear to be a factor affecting the verbal inquiry patterns of the preservice teachers.

Koran (51) also worked with preservice elementary school teachers enrolled in a science education methods course. He compared the results of telling teachers how to teach with presenting a filmed model of the behavior to be acquired. Evidence for this comparison was gathered from the students' performance under simulated conditions in which they were asked to generate questions in written form.

The "telling" portion of the study consisted of a four hour session in which the students worked with materials from "Science: A Process Approach" while discussing the objectives of the lessons, lesson format, and teaching strategies used. The filmed model consisted of a fourteen minute videotape of a teacher conducting a science lesson with four elementary school children. In this model, the teacher's observation and classification questions were highlighted (51:217).

When Koran analyzed the data obtained, he found the students who had viewed the videotaped model of questioning scored significantly higher on both within group and between group differences than did the two control groups (specific instruction but no filmed model; no treatment) (51:222).

Johnson (44), working with inservice elementary school teachers in a summer program designed for teachers of children from disadvantaged areas, selected teachers' questioning behavior as an item for further analysis. Five teachers participated in a follow-up study in which

Johnson attempted to develop a model program for improving questioning behavior in science instruction. These five teachers were videotaped for three twenty minute science lessons in their schools, using the perform-analyze-perform approach. Johnson found, from a preliminary analysis of data, evidence to suggest important gains in both quality and quantity of productive thinking questions asked.

Rowe (68) investigated the verbal behavior patterns of inservice elementary school teachers as they taught science lessons. Question-asking techniques were analyzed to discover which techniques were most effective for teaching science when using some of the newer elementary school science programs (68:11). Rowe and her colleagues experimented to test the effect of (1) increasing the length of time a teacher waits for a student response, (2) increasing the length of time a teacher waits before responding to a student, and (3) decreasing the pattern of reward and punishment delivered to students. Rowe found that if teachers increased the average "wait-time" to five seconds or longer, after asking a question, the length of student responses to questions increased (68:12) and that, as teachers increased their "wait-time," they began to exhibit more flexibility in the kinds of questions they asked (68:13).

Konetski (50) worked with preservice secondary school science teachers and attempted to change the number of divergent and evaluative questions they asked as well as the total number of questions asked. Students enrolled in a course in methods of teaching high school science were pretested and grouped on the basis of the proportion of divergent and evaluative questions they had asked while teaching a short science lesson. An equal number of high-ranking and low-ranking students was then randomly assigned to experimental and control groups. Those in the experimental group were provided with a programmed instructional booklet designed to help them improve their questioning. Students in the control groups received only informal instruction (a handout) on questioning.

The experimental groups worked on two instructional strategies. One of these was aimed at developing skill in classifying questions. The other was designed to develop ability to construct questions for inquiry-oriented science lessons. Students in both experimental and control groups had individual conferences with their laboratory instructor in which the student's questioning practices in relation to the use of divergent and evaluative questions were discussed.

Students taught two more short science lessons which were recorded and analyzed. For purposes of data analysis, Konetski grouped questions as either (1) cognitive-memory and convergent or (2) divergent and evaluative. He concluded, after classifying and analyzing the questions identified in the tape recordings of the lessons, that (1) instruction provided for the experimental group significantly and positively affected the number and proportion of divergent and evaluative questions asked, (2) instruction also significantly and negatively affected the total number of questions asked, and (3) student-instructor conferences were more effective in producing desired changes in questioning behavior when used in conjunction with a formal program of instruction on questioning (50:11).

To summarize, the few studies reported here provide insufficient basis for making generalizations. Again, the concern appears to be primarily that of improving the cognitive level of the teacher's questioning behavior. Some of the experimenters were able to report a decrease in the number of low level questions asked. There are no data concerning the number of questions asked in a given period of time although some researchers reported a decrease in the total number of questions asked. The relation of questions to science content was not considered in any of the experimental studies. No comparisons of the questioning behaviors of preservice and inservice teachers can be made, nor can comparisons of teachers at different grade levels be considered in the studies cited.

SUMMARY

Although the effective use of the question as a teaching device has been a concern of educators for many years, it has been only within the past decade that formal attempts have been made to devise and test programs designed to help teachers improve their questioning skills.

The total number of studies cited, in science and in other content areas, is insufficient for generalizing. More research needs to be done concerning questions and student achievement, variation of questioning behavior with different grade levels and with different science content areas, the relation of the pacing of questions and their cognitive level and the student responses elicited, and possible relationship of teacher characteristics to questioning behavior. The majority of the research which has been done has been in social studies classrooms. The possibility may exist that this subject is most amenable to research and experimentation. Testing the validity of this assumption might provide a research topic.

Based on the literature cited in this chapter, it does appear reasonable to assume that (1) questions can be classified, with the classification system varying with the investigator's purpose; (2) teachers generally tend to ask lower level questions, teaching experience or lack of it and content area not withstanding; (3) teachers tend to ask frequent questions and fail to provide a sufficient length of time for students to think out an adequate response; (4) instructional programs can be designed for use in modifying questioning techniques; (5) those instructional programs which have been designed to modify questioning behavior in science have been primarily at the elementary school level; (6) there is little or no evidence that attempts have been made to help secondary school teachers increase the length of time they pause after asking a question or to reduce the number of questions they ask per class session; and (7) the use of such techniques as videotaping the teacher's performance or microteaching increases the amount of change an individual makes.

More systematic attempts to improve questioning behavior need to be devised and carried out, especially in science education. The majority of investigations in science involved elementary school teachers, both preservice and inservice. Few attempts appear to have been made to improve the questioning skills of prospective secondary school science teachers. It would appear that this area is in need of experimental research.

CHAPTER III

METHODOLOGY

INTRODUCTION

This chapter consists of a discussion of the population involved, design of the study, data-gathering instruments and procedures, and development of materials used in the study. It also includes a brief description of events in each of the four quarters of the study and of the procedures used in analyzing the data.

Population

During the first quarter, the subjects involved were undergraduates not yet enrolled in student teaching and experienced teachers who were members of an Academic Year Institute. Participation was on a voluntary basis. During quarters two, three and four, students enrolled in Education 587.27 (Student Teaching in Secondary Schools: Science) participated as a required part of this course. These individuals were randomly assigned, prior to the beginning of each quarter, to one of four groups, as shown in the table on the following page.

Table 1. Distribution of the Population of the Study

Quarter	Spring 1969	Autumn 1969	Winter 1969
R_1	5	3	3
R_2	4	3	2
R_3	4	4	4
R_4	4	4	4
N	17	13	12

The treatment given each of these randomly assorted groups will be discussed in another section of this chapter.

Design of the Study

The Solomon Four-Group Design, with some modifications, was chosen for use because it provides flexibility and generalizability. Campbell and Stanley (13:194-195) state that generalizability is increased through the use of a Solomon Four-Group Design and the effect of the treatment is replicated in four different fashions.

The Solomon Four-Group Design (13:178,194) may be diagrammed as follows:

$$\begin{array}{llll} R & 0_1 & X & 0_2 \\ R & 0_3 & & 0_4 \\ R & & X & 0_5 \\ R & & & 0_6 \end{array}$$

In this diagram X designates a treatment; 0, an observation or measurement.

The modification of the Solomon Four-Group Design used in this study was:

$$\begin{array}{llll} R_1 & 0_1 & X_1 & 0_2 \\ R_2 & 0_3 & X_2 & 0_4 \\ R_3 & 0_5 & & 0_6 \\ R_4 & & & 0_7 \end{array}$$

In the usual Solomon Four-Group Design, only two of the four groups are pretested. The decision was made to pretest three of the groups to acquire data on questioning ability prior to student teaching.

Two different treatments were involved in this study: X_1 involved serving as teacher during the instructional sequence; X_2, as student-evaluators. This precluded using the third group as originally specified in the Solomon Four-Group Design unless a fifth group were to be added so that each of the treatments could be assessed without the pretest measure. The size of the population available was not large enough to add this fifth group. The modification made it possible to make both within group and between group comparisons.

The study consisted of two parts. During the first part, the subjects involved were tested to gain information concerning several factors which might be related to questioning skill. In addition, the instructional sequence designed to improve skill in questioning was carried out, with the accompanying pretesting and post-testing of the four groups. In the second part of the study, information was collected to determine the effects of the instructional sequence and/or the student teaching experience on questioning skill. Randomly selected individuals from each of the randomly assorted groups were observed during student teaching. Audiotape recordings were made of three lessons during student teaching. Data from these audiotape recordings were obtained to use in determining if the skill acquired during the instructional sequence transferred to the reality of the public school classroom and to determine some of the effects of time and experience as a student teacher on an individual's questioning skills. Audiotapes were made of a class session during the first week the student teacher assumed full responsibility in his assignment, during the midpoint of the quarter, and during the last week of student teaching. The diagram of the total design of the study is found on the following pages, Figure 1.

TREATMENTS FOR PART ONE

There were four treatments involved in this study in the sense that the varying amounts of participation of each of the four groups may be considered as "treatments." Part one of the study consisted of the administration of the written instruments used for collecting data relative to factors which might be related to questioning skill and of the instructional sequence with its accompanying pre- and post-tests and microteaching sessions.

Group R_1

A. Pretest: Students were asked to prepare and teach a ten to fifteen minute discussion lesson in science, using a topic chosen from content involved in their student teaching assignment. Level of presentation was to be that of the grade they would be student teaching. The lesson was videotaped.

Pupils for this and subsequent microteaching sessions were volunteers enrolled in Education 511: Elementary Education, Science.

Part I: Beginning of Student Teaching Quarter

R_1 O_1 X_1 O_2

Assignment by random selection to participate in instructional sequence (handbook on effective questioning techniques, discussion of questioning, teach three microteaching lessons of the teach-reteach variety). Pre- and post-test measures are videotaped microteaching sessions.

R_2 O_3 X_2 O_4

Assignment by random selection to serve as student-evaluator for microlessons. All will serve an equal number of times. None will serve in more than three sessions. Individuals will be pre- and post-tested as above.

R_3 O_5 O_6

Assignment by random selection to participate only in pretest and post-test measures. Individuals teach a short lesson in science.

R_4 O_7

Assignment by random selection to participate in post-test measure only, to determine effect, if any, of pretest measure on questioning technique.

R = randomly selected group
O = pre- or post-test measure
X = treatment

Figure 1. Diagram of the Study

Part II: During Student Teaching Quarter

R_1 $O_{1.1}$ $O_{1.2}$ $O_{1.3}$

Randomly selected individuals will be observed during the first week they have full responsibility in their student teaching, during the middle of the quarter, and during the final week of student teaching. Lessons observed will be audiotaped.

R_2 $O_{2.1}$ $O_{2.2}$ $O_{2.3}$

Same explanation as given for sample R_1 applies here.

R_3 $O_{3.1}$ $O_{3.2}$ $O_{3.3}$

Same explanation as for R_1. This allows for comparison of effects of time and experience on questioning skill.

R_4 $O_{4.1}$ $O_{4.2}$ $O_{4.3}$

Same explanation as that given for R_1 applies here, also.

$R\_$ = randomly selected individuals from randomly assorted groups
$O\_.\_$ = audiotaped observation in the classroom during student teaching experience

Figure 1. Diagram of the Study (continued)

B. Treatment: The instructional sequence *per se* lasted for a three week period. Prior to beginning the sequence, the R_1 student teachers met with the investigator to discuss the purpose of the study and benefits they might attain. At this initial meeting, which followed the pretesting, the subjects were given some written materials (a handbook on questioning, written by the investigator, and a sheet of instructions detailing the objectives of the first microteaching session) and were asked to become familiar with the general format of the Question Category System contained in the handbook prior to the teach lessons of Microteaching Session I. At a second meeting, a week later, the category system and the strategies described in the handbook were discussed. Following this meeting, the instructional sequence, consisting of three microteaching sessions of the teach-analyze-reteach variety, began.

Microteaching Session I (teach-reteach) involved the use of open questions as well as closed questions and the use of questioning techniques aimed at decreasing teacher talk.

Microteaching Session II involved attempting to use more open questions than closed questions and pausing after asking an open question, to allow pupils to think before responding.

Microteaching Session III was designed to provide the R_1 subjects with an opportunity to combine the strategies used in sessions I and II.

R_1 individuals were given specific suggestions relative to each strategy five days prior to the teach portion of the microteaching session. They were also provided with copies of the evaluation form to be used with the session. At the end of each lesson, the R_1 people viewed their taped teaching performance and were given the written evaluations of their pupils.

Teach and reteach portions of each microteaching session were separated by one day, to allow the teachers time to make any modifications they deemed desirable for improving their performance.

C. Post-test: Subjects were asked to reteach the same lesson topic they had used for their pretest lesson. They were permitted to make any changes they considered necessary to improve their teaching performance. Post-testing took place approximately four to five weeks after pretesting. Lessons were videotaped.

Group R_2

A. Pretest: These individuals received the same instructions concerning the pretest as did the members of group R_1.

B. Treatment: The week before the instructional sequence began, the investigator met briefly with the members of R_2. These people were told only that they had been randomly selected to serve as students and evaluators for the members of group R_1. They were asked to attend one of the microteaching sessions (teach or reteach) each week, to participate as pupils during the lesson, and to evaluate the teacher's performance at the end of the lesson, using an evaluation form they would receive at the beginning of the lesson. (All R_2 people attended at least two microteaching lessons each quarter, with over half of the total group for the three quarters attending all three sessions they were requested to attend.)

C. Post-test: The same instructions as those given R_1 people were used.

Group R_3

A. Pretest: Same instructions and circumstances as those described for group R_1 applied here also. These persons were told, when they completed the pretest lesson, that they had no further obligations to the study in the form of microteaching until post-test time arrived.

B. Treatment: None.

C. Post-test: Same instructions and procedures were used as those specified for R_1.

Group R_4

A. Pretest: None. (Prior to pretesting, these individuals were told they had been chosen, by random selection, to participate only in the post-test measure.)

B. Treatment: None.

C. Post-test: One week before post-testing, these persons were contacted and asked to prepare a ten to fifteen minute discussion lesson involving science content they had been teaching in the public schools. They were asked to aim the level of the presentation at the population with whom they were working during student teaching. They were also told that their pupils for the microteaching lesson might, or might not, possess a science content background comparable to that of their secondary school pupils.

Summary

All of the students participated in part one of the study. The degree of participation varied with the group to which the student had been randomly assigned. The situation may be summarized as follows:

Group	Degree of Involvement
R_1	Pretest, teacher for six microlessons in instructional sequence, post-test
R_2	Pretest, student-evaluators for three lessons in instructional sequence, post-test
R_3	Pretest, post-test
R_4	Post-test only

TREATMENT FOR PART TWO

Part two consisted of audiotaping some of the student teachers, at three different points in time, during their student teaching experience. Randomly selected individuals from each of the four randomly assorted groups were audiotaped during student teaching. Each was individually contacted by the investigator and informed of having been chosen, by a random selection process, for additional observation. They were told they would be allowed to choose the particular lesson, within the given period of time for each taping session, to be recorded. They were asked to continue the second and third taping sessions with the class they selected to be taped the first time.

These student teachers were assured that their performance, during the observation and taping, would in no way affect their student teaching evaluation. They were given the choice of doing their own taping, with the necessary equipment being supplied by the investigator, or of having the investigator present to do the taping. If a student teacher chose to do his own taping, he was asked to submit a brief written description of the lesson content, objectives, and activities to supplement the audiotape.

Lessons were recorded during the first week the student teacher was given full responsibility for the classes he was teaching, during the midpoint of the quarter, and during the final week of student teaching. The entire class period was recorded on tape. Analysis was confined to a randomly selected fifteen minute portion of the class period, however, in order to compare the questioning behavior of the student teacher with that which he exhibited during the fifteen minute microteaching session.

Because of the limitations of the recording equipment and because of the large percentage of managerial questions heard in laboratory situations when classes were observed during the first quarter of the study, only lessons in which the major portion of the class time was spent in discussion-type activities were tape recorded. Two exceptions to this procedure occurred during the final quarter of the study. In one case, a false alarm for fire had disrupted the daily schedule. In the second, the student teacher was scheduled to do primarily laboratory work during the week in which the second taping was to be completed.

Questions identified in the pre- and post-test videotapes and in the audiotapes were transcribed and typescripts of each lesson were made. The tapes and typescripts were used in the analysis and classification of the teacher's questions and questioning techniques.

DEVELOPMENT OF MATERIALS

Question Category System

An overall objective of this study was to develop a tool that would be of use to both preservice and inservice teachers. A review of literature resulted in the identification of a variety of question classification systems. None of these appeared to fully satisfy all three of the following criteria: (1) that the system be teachable,

(2) that it cover the variety of questions asked in science classes, and (3) that it could be used by preservice teachers to analyze their own and other teachers' questioning behavior.

The Question Category System was tested in live observations in the classrooms of experienced teachers and of student teachers to determine whether the categories were inclusive enough for the purposes of the study. The system was modified and used to analyze questions identified in lessons videotaped during the first quarter of the study. It was also submitted to other graduate students and to the investigator's major adviser for use and criticism. The form used in quarters two, three and four of the study is shown in Figure 2 on the following page.

Both the category system and the handbook were given to eight student teachers, not involved in the study, for critical review and evaluation as well as to a second member of the dissertation committee whose field of competency is instruction. Based on feedback from these individuals, further modifications were made before the second quarter of the study began.

Handbook of Effective Questioning Techniques

The materials in the handbook were developed from the investigator's experiences as a secondary school science teacher and from ideas gained from a survey of some of the literature related to questions and questioning. The handbook was developed prior to the pilot study (first quarter) and later underwent several revisions during the first

QUESTION CATEGORY SYSTEM		
LEVEL I	LEVEL II	LEVEL III
I. CLOSED QUESTIONS (limited number of acceptable responses)	A. COGNITIVE-MEMORY*	1. RECALL: includes repeat, duplicate, memorized definitions 2. IDENTIFY or NAME or OBSERVE
	B. CONVERGENT THINKING*	1. ASSOCIATE and/or DISCRIMINATE; CLASSIFY 2. REFORMULATE 3. APPLY: previously acquired information to solution of new and/or different problem 4. SYNTHESIZE 5. CLOSED PREDICTION: limitations imposed by conditions, evidence 6. MAKE "CRITICAL" JUDGMENT: using standards commonly known by class
II. OPEN QUESTIONS (greater number of acceptable responses)	C. DIVERGENT THINKING*	1. GIVE OPINION 2. OPEN PREDICTION: data insufficient to limit response 3. INFER or IMPLY
	D. EVALUATIVE THINKING*	1. JUSTIFY: behavior, plan of action position taken 2. DESIGN: new method(s), formulate hypotheses, conclusion(s) 3. JUDGE A: matters of value, linked with affective behaviors 4. JUDGE B: linked with cognitive behaviors
III. MANAGERIAL	Teacher uses to facilitate classroom operations, discussion	
IV. RHETORICAL	Teacher uses to reinforce a point; does not expect (or want) a response	

*1. Cognitive-memory: evidence understood to be directly available (book, previous lesson or discussion, film or filmstrip, chart)
2. Convergent thinking: evidence directly available but not in form called for by question
3. Divergent thinking: evidence for response not directly available
4. Evaluative thinking: evidence may or may not be directly available; criteria for responding available, directly or indirectly. Contains implication that student may be called upon to provide a defense for his response.

Figure 2. Question Category System

and second quarters of the study. The fourth and final revision was completed during the second quarter of the study and consisted primarily of adding a fourth appendix.

The handbook contains a discussion of some characteristics of effective questions (those which elicit the type of response the teacher hoped to stimulate), functions questions may serve in a lesson, and the use of questioning as a teaching strategy. It also contains a chapter dealing with the Question Category System and explanations of its parts. The final chapter consists of a discussion of the teaching strategies to be used in the instructional sequence: (1) asking open questions as well as closed questions and (2) using questioning techniques that decrease teacher-talk. In addition, the handbook contains four appendices, each developed to provide more guidance for preservice teachers as they plan their lessons for the instructional sequence.

A copy of the handbook may be obtained through the ERIC Document Reproduction Service. Communications may be addressed either to the investigator or to the ERIC Center for Science and Mathematics Education, 1460 West Lane Avenue, Columbus, Ohio 43221.

INSTRUCTIONAL SEQUENCE

Some format was necessary whereby the individuals in R_1 could be provided with opportunities to develop their questioning skills. The ideal situation would have been to provide them with pupils of the same age and grade level as they would encounter in student teaching. This, however, was not possible. There was a population available on campus which possessed some degree of similarity to secondary school pupils with respect to level of sophistication in science content. This population also was relatively large. It consisted of those students preparing for careers as elementary school teachers.

Student-Evaluators

The individuals who served as pupils and evaluators for the instructional sequence and for the pre- and post-test lessons were drawn primarily from students enrolled in Education 511, Elementary Education: Science, a general methods course on teaching science in the elementary school. Members of group R_2 also served as student-evaluators for the instructional sequence but not for the pretest and post-test lessons.

Students enrolled in Education 511 are required to have only six quarter hours of college science in order to qualify for certification as an elementary school teacher. Additional certification requirements preclude any degree of specialization in science content. Enrollment in Education 511 is sufficiently large so that the same people did not have to serve as students for more than two or three of the lessons, thus eliminating the addition of another obligation to an already crowded student schedule.

The study was explained to each of the Education 511 sections during the first week of each of the data-gathering quarters of the study. The investigator and the Education 511 instructor described the study, explained the function of the student-evaluators, and pointed out the possible benefits these individuals might derive from their participation. The students were asked, if they chose to participate, to attend two or three lessons (either the teach or reteach lesson of a microteaching session but not both) in order to develop some perception of the intent of the study.

The student-evaluators were briefed, during the investigator's initial contact with their Education 511 class, on the strategies the R_1 people would be attempting to demonstrate. Several copies of the handbook were placed on closed reserve with other library materials in their science classroom. In addition, prior to the beginning of each microteaching lesson, the student-evaluators were reminded of the strategy to be displayed. At the end of the lesson they completed an evaluation checklist keyed to the particular strategy involved in the session and added any comments they deemed pertinent. Although they played dual roles as students and as evaluators, their involvement at any one time was limited to about thirty minutes, through the use of microteaching.

Microteaching

The survey of the literature provided an indication that other researchers had achieved some degree of success in using microteaching as a vehicle for instruction as a part of teacher education programs emphasizing "the technical skills approach" to teacher education described by Gage (34). Microteaching has been a part of the teacher education program at Stanford University since 1963 (Bush, 11). Microteaching, at Stanford, involves teaching a short (five to ten minute) lesson to a small group (four to eight) of students.

One of the Stanford studies, by Orme (62), involved the use of five minute lessons. In another study (Salomon and McDonald, 68), teachers taught fifty minute lessons. Almost all of the studies, with the exception just cited, possessed the common characteristics of (1) teaching short lessons, (2) to a small group of students, with (3) the lesson being recorded, usually on videotape, for study and evaluation by the teacher and a supervisor, and then (4) reteaching the same content to a different group of students. The pupils involved in each of the micro-lessons had been briefed concerning the skill the teacher would be attempting to exhibit. At the end of each lesson these pupils evaluated the teacher by completing evaluation forms.

Studies reported by Borg (7), Claus (15), Koran (52), and Orme (62) involved investigation of questioning skill in microteaching situations. Microteaching appeared to have been used widely and frequently enough to be considered as a useful tool in teacher education and was, therefore, selected as the means whereby the members of group R_1 would have the opportunity to practice questioning techniques. By teaching lessons of limited duration, they would have an opportunity to interact as teachers more often with more pupils than if they were to teach lessons of the conventional forty minute length.

Modifications of Microteaching

A ten to fifteen minute lesson was considered minimal to provide an adequate sampling of a teacher's questioning behavior. Although Orme (62) reported the use of a five minute lesson, this did not seem an adequate length of time in which to develop a topic and to ask questions about it. The first modification was to increase the length of the microteaching lesson to fifteen minutes.

A second modification was that the teach-reteach portions of the microteaching sessions were separated by one day. In the early Stanford situation, the teach-reteach portions of the lessons are separated by an interval of only fifteen minutes. Such a short period of time seemed inadequate if the teacher wished to make any major modifications in content or its presentation.

The student teachers in group R_1 taught a lesson on Tuesday, were videotaped, received evaluations from their pupils, viewed their videotaped teaching performance, and evaluated it with the investigator. The primary responsibility for identifying areas in need of improvement was placed on the student teacher. The investigator did, if circumstances demanded it, suggest modifying certain behaviors or emphasizing others. The process was primarily one of self-evaluation, based on the assumption that changes in behavior are more likely to occur if the perception of need for such changes arises from within the individual rather than from being imposed by a supervisor. On Thursday, of the same week, the student teacher retaught the lesson to a different group of student-evaluators.

During the third and fourth quarters of the study, the members of group R_1 received copies of the typescripts of the questions they had asked in the previous lesson; e.g., on Thursday they received the typescript of Tuesday's lesson. Although they did not receive the material in time to use it in planning any modifications for the reteach lesson, they were able to analyze their questions as they considered ways in which their questioning techniques could be improved.

DATA GATHERING INSTRUMENTS AND PROCEDURES

Data gathering procedures consisted of those related to student teacher characteristics and involved the administration of some written instruments as well as those related to questioning behavior exhibited in the microteaching lessons and in the student teaching assignments. Data relative to questioning behavior were recorded through the use of videotape and audiotape.

Written Instruments

The written instruments were administered to all of the student teachers during one of the seminar meetings early in each quarter. These measures consisted of the Otis Quick Scoring Mental Ability Test, Gamma Test, Form Em (63), to measure intelligence; the Myers-Briggs Type Indicator, Form E (60), to measure personality type; and the Educational Set Scale (73), to measure cognitive style as exemplified through educational set. Brief descriptions of each of these instruments are found in Appendix B of this dissertation.

Videotaping Procedures

The participants involved in the study were videotaped during the pre- and post-test lessons as well as during the microteaching lessons of the instructional sequence. The investigator monitored the equipment for each of the taping sessions.

Although the study was principally concerned with the questions student teachers asked, videotaping was chosen as the means for gathering data. Several factors influenced this decision. One, science lessons frequently involve nonverbal activities such as experiments and demonstrations. The use of videotape provided a record of such activities and promoted better recall of the context of the teacher's questions than would a written description of the nonverbal behavior that had taken place. Two, the student teachers participating in the study hoped to benefit as much as possible from their participation. The investigator felt that these individuals would become more aware of their teaching behavior if they saw as well as heard themselves.

Audiotaping Procedures

The investigator had originally intended to gather data in the public schools via videotape. However, the equipment was heavy and not easily transportable by one individual. In addition, experienced teachers had been videotaped during the pilot study and were uncomfortable with the equipment in their classrooms. The investigator decided that the use of an audiotape recorder supplemented by written notes of the observations would be an adequate substitute for videotape records. The microphone and tape recorder were placed in the classroom so that the teacher's voice was audible on tape. Many of the student responses could also be heard although the fidelity was marred in some classrooms due to acoustical problems.

If the study were to be expanded to include analysis of student responses to teacher questions, additional and more sensitive equipment would be needed to overcome the acoustical handicaps present in most public school classrooms.

THE STUDY

Quarter One

The pilot study took place during Winter Quarter, 1968-1969. During this quarter, the Question Category System, the handbook, and the instructional sequence were tested. The individuals participating in the study were volunteers enrolled in either Education 625, Practicum in the Bilogical Sciences, or Education 627, Practicum in the Physical Sciences. This was a mixed population of undergraduates majoring in secondary school science education and experienced teachers who were members of an Academic Year Institute.

In addition, a group of students enrolled in Education 587.27 (Student Teaching in Secondary Schools: Science) served as critics and evaluators for the category system and the handbook. These people were not involved in the instructional sequence. They were spending at least half of every school day in the public schools and thus provided a perspective that the undergraduates enrolled in the practicum courses lacked.

Quarter Two

In the Spring Quarter, 1968-1969, individuals enrolled in Education 587.27 participated in the study as a part of their student teaching duties. Those persons who had been involved in the pilot study during the preceding quarter were eliminated from this sample.

The remaining individuals were randomly assigned to the four treatment groups described earlier in this chapter.

Due to scheduling difficulties during the second part of the study in quarter two, each of the student teachers randomly selected for audiotaping was observed and taped only one time rather than the three times originally planned. This observation took place near the end of the student teaching assignment.

Quarters Three and Four

During the Autumn and Winter Quarters of 1969-1970, students enrolled in Education 587.27 participated in the study. The procedures detailed in earlier parts of this chapter were carried out. These individuals had received the Educational Set Scale (73) as a part of a test battery in one of their science education methods courses. This test was not readministered, saving time and allowing the investigator to begin procedures preliminary to pretesting earlier in these quarters than had been possible in quarter two.

ANALYSIS OF THE DATA

Written Instruments

The three tests used for data gathering purposes were hand-scored. These scores were recorded for each of the second, third and fourth quarters of the study. During the fourth quarter of the study, each of the forty-two students involved was assigned a code number. Test scores were recorded on a master list, identified only by the student teacher's code number, for use in sorting during data processing.

Videotaped Lessons

Three science educators, members of the Faculty of Science and Mathematics Education, served as judges for part one of the study. These individuals met with the investigator during the third quarter of the study for purposes of orientation and training in the use of the Question Category System. The training sessions involved the use of microteaching lessons videotaped during the first quarter of the study and of lessons from the instructional sequence portions of the second and third quarters of the study. Judges were supplied with the typescripts of the questions asked in each lesson.

After the training sessions, the videotapes to be judged were coded so that it was not possible to identify whether the recording was that of a pretest or a post-test lesson. Nor was it possible to identify from the coding the treatment group to which the student teacher belonged. The tapes, a videotape recorder and a monitor were placed in a location convenient to the judges. The questions identified in each lesson were numbered consecutively as they occurred in the typescript. Using the typescripts while they viewed the tapes, the judges worked individually in their analysis and coding of the questions. This analysis took place near the end of the fourth data gathering quarter of the study and continued during the following quarter.

Each judge used the Question Category System to classify the teacher's questions during the microteaching sessions. The final classification assigned to a particular question was based on the agreement of the majority of the judges involved. In some cases all three judges agreed in their rating at each of the three levels of the category system. In some cases two of the three judges agreed in their ratings. In those instances in which no two judges agreed on the same classification at a particular level, this lack of agreement was noted and recorded.

Audiotaped Lessons

The questions identified in the lessons taped in the public schools were also transcribed and made into typescripts. Although the average class period was forty minutes in length, only fifteen minute segments of the verbal interaction were analyzed in order to maintain the standard of comparison with the fifteen minute microteaching lessons. The segment to be analyzed was randomly selected by the use of a random number table. Only random numbers ranging from one to twenty-five were used to insure that a fifteen minute sequential segment of the lesson would be chosen for analysis.

Classification of the questions from the audiotaped lessons was done by the investigator. Each of the seventeen lessons recorded during the final week of student teaching was analyzed three times, with each of the analysis sessions being separated by one to two week intervals.

Determination of Rater Reliability

Calculations were made of the reliability of the average of the judges' ratings as well as those of the investigator. The reliability of the judges was obtained using data from quarters two and three of the study. Data obtained from the analyses of the audiotapes of the third lesson recorded in the public schools were used to determine the reliability of the ratings done by the investigator.

Reliability of the average of the judges' ratings was determined as specified by Guilford (39:300), using a modified form of a formula for intraclass correlation. Data used to make the calculations were obtained by processing the coded question classifications in a BMD 02V program, analysis of variance for factorial design, using an IBM 360 computer.

This formula specified for intraclass correlation is:

$$r_{kk} = \frac{V_r - V_e}{V_r}$$

where V_r = variance between rows (in this study, a specific question)
V_e = variance for residuals (or error).

The results of the calculations are shown in Table 2, below.

Table 2. Reliabilities of Raters

Category Level	Average of Judges	Investigator
I	.73	.92
II	.70	.91
III	.70	.90

Techniques Used to Test the Hypotheses

Data obtained from the analyses of the videotaped microteaching lessons and from the randomly selected fifteen minute portions of the audiotaped classroom lessons were coded for computer programming to test the seven hypotheses involved in the study.

Hypothesis 1. Skill in questioning as a teaching technique cannot be developed through practice and experiences involved in an instructional sequence.

Data obtained from the analysis of the microteaching lessons were submitted to programs for correlation, for stepwise regression analysis, and for analysis of variance for one-way design.

Hypothesis 2. There is no effect of treatment (teacher of a microclass, pupil in a microclass, member of a control group) on questioning behavior of a preservice teacher.

Data obtained from the post-test microteaching lessons and from the third lesson recorded in the schools were analyzed, using correlation, stepwise regression, and analysis of variance for one-way design.

Hypothesis 3. The skill developed during the instructional sequence will not transfer to the student teaching experience in the public schools.

Data from the post-test lessons (after the instructional sequence) were compared with data obtained from analysis of the lesson audiotaped during the final week of student teaching for each of the three data gathering quarters of the study. These data were subjected to correlational analysis and to analysis of variance for one-way design.

Hypothesis 4. There is no relationship between intelligence and questioning ability.

Hypothesis 5. There is no relationship between sex and questioning ability.

Hypothesis 6. There is no relationship between educational set and questioning ability.

Hypothesis 7. There is no relationship between personality type and questioning ability.

The validity of these hypotheses was tested primarily through the use of program BMD 02D, correlation with transgeneration. Hypotheses six and seven were also tested using BMD program 02R, stepwise regression.

CHAPTER IV

ANALYSIS OF RESULTS

This chapter consists of two parts. The first part contains a description of the sample involved in the three data-gathering quarters of the study. The second, and major, part of the chapter consists of the presentation of the seven hypotheses of the study, the data used in determining whether each hypothesis was rejected or not rejected, and an interpretation of these data.

Description of the Subjects

Forty-two prospective secondary school science teachers participated in the study. These individuals were enrolled, at the time of their participation, in Education 587.27, Student Teaching in Secondary Schools: Science. All had been enrolled in two science education courses, a general methods course and a practicum course relating to one of the major science content areas (biological science, physical science, earth science). Seventy-four per cent of the individuals were male. Table 3, page 69, shows the distribution of the subjects in the treatment groups by sex.

Student teaching assignments varied for different content areas in different quarters. Approximately thirty-three per cent of the subjects did their student teaching in biology; twelve per cent, in chemistry;

Table 3. Distribution of Subjects in Treatment Groups by Sex

	R_1		R_2		R_3		R_4	
Quarter	Males	Females	Males	Females	Males	Females	Males	Females
Spring 1969	4	1	3	1	1	3	4	0
Autumn 1969	2	1	2	1	3	1	2	1
Winter 1969	3	0	1	1	3	1	3	0

twenty-four per cent, in earth science; four per cent, in physics; twenty-four per cent, in general science. The group was almost equally divided between teaching assignments in the junior high school (twenty people) and the senior high school (twenty-two people). The majority of the schools to which these people were assigned could be classified as suburban. Only four student teachers were assigned to schools classified as inner-city. Table 4, page 70, shows the distribution of the subjects in the treatment groups by science area for student teaching.

The majority of the student teachers were completing their undergraduate education. Two of the forty-two individuals already possessed undergraduate degrees but had not previously prepared for careers in education.

Variables Measured

Thirty-seven variables were measured for this study. Information was derived from several sources: the Otis Quick Scoring Mental Ability Test, Gamma Test, Form Em (abbreviated to Otis); the Myers-Briggs Type

Table 4. Distribution of Subjects in Treatment Groups
for their Student Teaching Experience

Content Area	Treatment Groups R_1	R_2	R_3	R_4
Biology	5	2	5	2
Chemistry	2	0	1	2
Earth Science	3	4	1	2
Physics	0	1	0	2
General Science	1	2	5	2

Indicator, Form E (MBTI); the Educational Set Scale (ESS); analysis of the questions identified in the videotaped and audiotaped science lessons (QA); student teaching records (STR); and the treatment group to which the individuals had been randomly assigned (RA).

These variables may be divided into two groups: Student Teacher Variables and Questioning Technique Variables. The first group includes those variables relating to intelligence, personality type, educational set, sex, student teaching assignment, and treatment group. The second group contains those variables relating to question types, pausing, and percentage of teacher talk. A listing of the variables and the source of information for each follows as shown in Figure 3. The abbreviations for the sources are those given in the preceding paragraph.

A description of the sample, based on Student Teacher Variables 1-24 is given in Table 5 on pages 72-73. A description of the sample, by quarters, for Student Teacher Variables 1-24 is found in Appendix C.

Student Teacher Variables	Source
1. Intelligence	Otis
2. Educational Set: total score	ESS
3. Educational Set: conceptual score	ESS
4. Educational Set: factual score	ESS
5. E-I continuum score	MBTI
6. S-N continuum score	MBTI
7. T-F continuum score	MBTI
8. J-P continuum score	MBTI
9. Extroversion	MBTI
10. Intraversion	MBTI
11. Sensing	MBTI
12. Intuition	MBTI
13. Thinking	MBTI
14. Feeling	MBTI
15. Judgment	MBTI
16. Perception	MBTI
17. Sex	STR
18. Student teaching assignment: biology	STR
19. Student teaching assignment: chemistry	STR
20. Student teaching assignment: earth science	STR
21. Student teaching assignment: physics	STR
22. Student teaching assignment: general science	STR
23. School level for student teaching	STR
24. Treatment group R_1	RA
25. Treatment group R_2	RA
26. Treatment group R_3	RA
27. Treatment group R_4	RA

Questioning Technique Variables	Source
1. Closed Questions	QA
2. Open Questions	QA
3. Managerial Questions	QA
4. Rhetorical Questions	QA
5. Cognitive-Memory Questions	QA
6. Convergent Thinking Questions	QA
7. Divergent Thinking Questions	QA
8. Evaluative Thinking Questions	QA
9. Pause Time	QA
10. Teacher Talk	QA

Figure 3. Variables Measured for the Study

Table 5. Means and Standard Deviations of Student Teacher Variables

Variable	Total Sample (N=42)		R_1(N=11)		R_2(N=9)		R_3(N=12)		R_4(N=10)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Intelligence[a]	124.36	7.78	122.09	7.16	124.67	7.16	123.67	8.51	127.40	8.19
Educational Set[b] Scale:total	27.12	11.28	23.36	14.29	33.44	7.11	29.75	8.78	22.40	11.08
Educational Set Scale:conceptual	35.26	7.15	32.82	9.06	39.11	5.23	36.67	5.21	32.80	7.24
Educational Set Scale:factual	8.14	4.45	9.45	5.45	5.67	2.29	6.92	4.01	10.40	4.14
Continuum Scores[c]										
E-I	92.21	23.24	92.83	27.03	96.56	21.56	85.83	23.46	95.30	21.87
S-N	110.95	26.71	119.55	24.22	114.78	22.61	106.00	33.81	104.00	23.57
T-F	92.95	21.28	100.64	23.01	93.00	25.51	88.00	20.24	90.40	16.84
J-P	106.24	28.37	109.91	28.47	108.11	31.70	105.00	29.04	102.00	28.29
Extroversion[c]	14.50	6.56	14.27	7.88	14.33	5.70	15.33	7.11	13.90	5.92
Intraversion	9.98	6.13	9.45	6.55	11.44	6.08	8.00	5.33	11.60	6.75
Sensing	8.05	7.42	6.00	6.71	5.00	2.96	10.25	9.54	10.40	7.43
Intuition	13.93	6.45	15.27	6.87	16.11	4.40	12.75	8.16	11.90	5.02
Thinking	10.83	5.78	8.18	6.31	11.11	6.15	12.58	5.90	11.40	4.33
Feeling	7.62	5.47	8.73	6.62	8.33	6.58	6.58	4.58	7.00	4.42
Judgment	11.40	6.71	10.09	6.55	11.22	7.87	11.75	6.74	12.60	6.54
Perception	14.21	7.43	15.18	6.92	14.78	8.10	13.83	7.99	13.10	7.68
Sex[d]	1.26	0.44	1.18	0.40	1.33	0.50	1.42	0.51	1.10	0.32
Student teaching[e]										
Biology	1.33	0.48	1.45	0.52	1.22	0.44	1.42	0.51	1.20	0.42
Chemistry	1.12	0.33	1.18	0.40	1.00	0.0	1.08	0.29	1.20	0.42

Table 5 (continued)

Variable	Total Sample (N=42)		R_1(N=11)		R_2(N=9)		R_3(N=12)		R_4(N=10)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Student teaching[e]										
Earth Science	1.24	0.43	1.27	0.47	1.44	0.53	1.08	0.29	1.20	0.42
Physics	1.07	0.26	1.00	0.0	1.11	0.33	1.00	0.0	1.20	0.42
General Science	1.24	0.43	1.09	0.30	1.22	0.44	1.42	0.51	1.20	0.42
School Level[f]	1.52	0.51	1.64	0.50	1.33	0.50	1.50	0.52	1.60	0.52

[a] Otis Quick Scoring Mental Ability Test, Gamma Test, Form Em

[b] Educational Set Scale by Siegel and Siegel

[c] Myers-Briggs Type Indicator, Form E

[d] Male coded 1; Female coded 2

[e] No coded 1; Yes coded 2

[f] Junior high school coded 1; Senior high school coded 2

Criterion Variables

Three of the questioning technique variables were chosen as criterion variables for this study: Open Questions, Pause Time, and Teacher Talk.

A student teacher was considered to have achieved some skill in questioning if he could use Open Questions in his teaching. It was assumed that preservice teachers customarily use Closed Questions, Managerial Questions, and Rhetorical Questions. It was also assumed that student teachers may not use Open Questions in their teaching unless they were made aware of such questions. Open Questions are defined as those to which there are a number of acceptable responses rather than a limited number of "correct" answers.

Encouraging students to think critically is an objective that appears with regularity in lists of objectives of science teaching. If students are to become critical thinking people, regardless of how the objective of critical thinking is defined, they need to be asked questions that require more than cognitive-memory thinking operations in the formulation of a response. If students are to go beyond the level of factual-recall, they need to have time to think before they are required to respond. The second criterion variable was that of pausing at least three seconds after asking a question classified as being at a level above factual-recall so that the students could be provided time to think before responding. The mean of the pause times for a lesson was used as this variable.

If science teachers are to encourage a spirit of inquiry in their classrooms and are to develop students who become independent learners, it would seem logical that the teacher should not dominate the learning situation and should assume the role of a resource person rather than that of an authority who is the final source of all information. If this premise is accepted, it would seem logical to assume also that teachers who serve as resource persons rather than authorities dominate the verbal interaction in the classroom less than those teachers who consider their primary responsibility that of dispensing information. Therefore, the third criterion variable was that of the percentage of teacher talk heard during the fifteen-minute period of analysis. The use of Open Questions and of questioning techniques designed to encourage more, and more extended, student responses should result in an increase in the amount of student response and a decrease in teacher talk.

ANALYSIS OF DATA

Each of the seven hypotheses of the study was stated in the null form. The alpha level chosen was that of .10 significance level. Two-tailed or nondirectional tests were used.

Hypothesis 1. Skill in questioning as a teaching technique cannot be developed through practice and experiences involved in an instructional sequence.

Skill in questioning as a teaching technique was considered to be exemplified by the following criterion variables: (1) percentage of open questions of the total number of questions asked during the fifteen minute period analyzed, (2) pausing, (3) decrease in percentage of teacher talk during the lesson.

Data from the post-test videotaped lessons, involving the fifteen minute microteaching situation, were subjected to correlational analysis, stepwise regression analysis, and one-way analysis of variance to test hypothesis one.

The results of the correlational analysis are given in Table 6 on this page. The critical value of the correlation coefficient was .257 for the .10 level of significance (df=40). There were no significant correlations for any of the question types of Level I of the Question Category System. There were significant correlations between membership in treatment group R_1 (teachers during the instructional sequence) and the behaviors of pausing and of decreasing teacher talk.

Table 6. Correlation of Treatment Group to Question Type, Level I, Pause Time Mean, Percentage of Teacher Talk

Variable	Treatment Groups			
	R_1	R_2	R_3	R_4
Closed Questions	-0.136	0.133	0.079	-0.072
Open Questions	0.178	-0.094	-0.007	-0.086
Managerial Questions	0.247	-0.075	-0.244	-0.076
Rhetorical Questions	-0.370	-0.064	0.226	0.204
Pause Time Mean	0.535*	-0.154	-0.214	-0.177
Teacher Talk	-0.477*	0.075	0.164	0.247

*Exceeds critical value for .01 level of significance

Although none of the correlation coefficients for the question types of Level I were at the alpha level, they provide evidence of a directional difference. This directional difference was in favor of treatment group R_1. In addition, only treatment group R_1 correlated positively with Open Questions and negatively with Closed Questions.

Stepwise regression analyses using Questioning Technique variables as dependent variables and Student Teacher Variables as well as selected Questioning Variables as independent variables were made. No single strong predictor was identified. Nor was any strong combination of two or three predictor variables identified, as indicated in Table 7, page 78. Stepwise regression analyses, for question types of Levels I and II of the Question Category System, for pause time mean, and for percentage of teacher talk are reported in Appendix D.

Data from the post-test lessons were also analyzed using BMD program 01V, Analysis of Variance for One-Way Design. The means of each treatment group were compared for each of the four question types of Level I, for pause time mean, and for percentage of teacher talk. The results are given in Table 8. The critical value of F = 2.26 for the .10 level of significance (df = 3,38) was identified only for Rhetorical Questions.

Table 7. Summary of Regression Analyses Using the Student Teacher Variables and Selected Questioning Technique Variables as Independent Predictor Variables of Questioning Skill

Independent Variable	Multiple R	Multiple R^2	Increase in Multiple R^2	df	F
		OPEN QUESTIONS			
Teacher talk	0.5016	0.2516	0.2516	1/40	13.4491
Student teaching: earth science	0.5477	0.3000	0.0483	2/39	2.6934
		PAUSE TIME (MEAN)			
Treatment group R_1	0.5348	0.2860	0.2860	1/40	16.0231
Student teaching: physics	0.6193	0.3836	0.0976	2/39	6.1721
Student teaching: chemistry	0.6591	0.4344	0.0509	3/38	3.4167
Teacher talk	0.6934	0.4808	0.0464	4/37	3.3084
E-I continuum score	0.7201	0.5185	0.0377	5/36	2.8175
		PERCENTAGE OF TEACHER TALK			
Closed Questions	0.5016	0.2516	0.2516	1/40	13.4491
Treatment group R_1	0.6376	0.4066	0.1550	2/39	10.1843
Sex	0.6883	0.4738	0.0672	3/38	4.8507
Convergent Thinking Questions	0.7168	0.5138	0.0040	4/37	3.0451
Student teaching: chemistry	0.7405	0.5483	0.0346	5/36	2.7542

Table 8. Analysis of Variance for Treatment Groups on Percentage of Question Types, (Level I) Asked During Post-test (Microteaching Lesson)

Source of Variance	Sum of Squares	df	Variance Estimate	F*
		CLOSED QUESTIONS		
Between	599.01	3	199.67	0.4714
Within	16095.93	38	423.58	
Total	16694.94	41		
		OPEN QUESTIONS		
Between	284.75	3	94.92	0.4730
Within	7624.80	38	200.65	
Total	7909.55	41		
		MANAGERIAL QUESTIONS		
Between	592.11	3	197.37	1.3543
Within	5538.12	38	145.74	
Total	6130.22	41		
		RHETORICAL QUESTIONS		
Between	368.27	3	122.76	2.6328
Within	1771.79	38	46.63	
Total	2140.06	41		

*F = 2.26 for significance at .10 level

The data involved in the analysis of variance for Rhetorical Questions were subjected to further testing by the method of multiple comparisons. The .10 level was also used in this analysis. An adaptation of the Scheffé method was applied to the data. The means for treatment groups R_1 through R_4 were 1.1473, 4.7000, 8.2167, 8.1750. The means for each group were compared, with the following results:

Comparison of Means	Difference
$R_1 - R_2$	3.55
$R_1 - R_3$	6.98

Comparison of Means	Difference
$R_1 - R_4$	7.03
$R_2 - R_3$	3.43
$R_2 - R_4$	3.48
$R_3 - R_4$	.05

Using the following formula[1], the critical difference between means was calculated.

$$\overline{X}_i - \overline{X}_j = \sqrt{(k-1)\ F(1-\alpha)\ (k-1, fe)\ \frac{2MSe}{n}}$$

α = level of significance

MSe = variance estimate (within groups)

n = harmonic mean (n) for these data, using unequal group sizes

The critical difference between means was then calculated.

$$\text{Critical difference} = \sqrt{(3)\ (2.26)\ \frac{2(46.63)}{10.5}} = 7.74$$

None of the differences between means equalled the critical difference.

One-way analyses of variance were also used with the variables of pause time mean and percentage of teacher talk for the four treatment groups. These are shown in Table 9.

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[1] This is an adaptation of the Scheffé method presented in a mimeographed paper entitled "Multiple Comparison Instructional Paper" by Arthur L. White, The Ohio State University, January 14, 1970 (unpublished).

Table 9. Analysis of Variance for Treatment Groups on Pause Time and Percentage of Teacher Talk for the Post-test (Microteaching Lesson)

Source of Variance	Sum of Squares	df	Variance Estimate	F
		PAUSE TIME MEAN		
Between	3.53	3	1.18	5.0798
Within	8.80	38	0.23	
Total	12.33	41		
		PERCENTAGE OF TEACHER TALK		
Between	2117.46	3	705.82	3.9472
Within	6795.00	38	178.82	
Total	8912.46	41		

The F value for both analyses of variance exceeded that needed for the .10 level of significance (2.26). Both sets of data were subjected to the method of multiple comparisons.

When the method of multiple comparisons was applied to the difference between means for each group for Pause Time, the following differences were identified:

Comparison of Means	Difference
$R_1 - R_2$	.65
$R_1 - R_3$	.67
$R_1 - R_4$	.66
$R_2 - R_3$	.02
$R_2 - R_4$	.01
$R_3 - R_4$	.01

The critical difference was calculated as follows:

$$\text{Critical difference} = \sqrt{(3)\ (2.26)\ \frac{2(0.2317)}{10.5}} = .52$$

The critical difference was calculated to be .52. When the critical difference was compared with the differences between means, three of the five differences exceeded the critical difference. All three involved the comparison of treatment group R_1 with each of the other treatment groups. This comparison is consistent with the positive correlation found between group R_1 and pause time mean.

The same procedures were followed when the means of the treatment groups for the variable of percentage of teacher talk were examined by the method of multiple comparisons.

A comparison of means resulted in the following information:

Comparison of Means	Difference
$R_1 - R_2$	13.74
$R_1 - R_3$	15.43
$R_1 - R_4$	18.08
$R_2 - R_3$	1.69
$R_2 - R_4$	4.34
$R_3 - R_4$	2.65

The critical difference was computed.

$$\text{Critical difference} = \sqrt{(3)\ (2.26)\ \frac{2(178.82)}{10.5}} = 15.20$$

The critical difference was computed to be 15.20. Two of the five differences exceeded the critical difference: $R_1 - R_3$, $R_1 - R_4$. Apparently participation as teacher in the instructional sequence resulted in the development of the skill of decreasing teacher talk to a degree that was significant when compared with no treatment (groups R_3 and R_4). Significant difference was not shown when the group participating as teachers (R_1) was compared with the group participating as student-evaluators (R_2).

Based on the analyses of the data presented on the preceding pages, the decision to reject or not to reject Hypothesis 1 must be considered for each of the behaviors involved: asking Open Questions as well as Closed Questions, Pausing, and Percentage of Teacher Talk (decreased percentage was the objective). When the behavior of asking Open Questions is considered, the evidence available is not significant for rejecting the hypothesis. When considering the behavior of Pausing, the evidence is significant at the .01 level for rejection of the null hypothesis. When considering the behavior of decreasing teacher talk, the evidence available is also significant at the .01 level for rejection of the null hypothesis.

Hypothesis 2. There is no effect of treatment (teacher of a microclass, pupil in a microclass, member of a control group) on questioning behavior of a preservice teacher.

The decision to reject or not to reject this hypothesis was based on the analysis of the same data presented in the discussion of Hypothesis 1. Additional data obtained from the analysis of the third lesson audiotaped during the student teaching quarter for a randomly selected subsample from each treatment group were also used.

During the Spring Quarter 1969 only one lesson per student teacher was audiotaped. The taping took place during the final week of the student teaching assignment. Because the time of the taping was comparable with that done in Autumn Quarter 1969 and Winter Quarter 1969, data from the three quarters were combined for the analysis. These data are referred to as "third audiotape" data in subsequents parts of this discussion.

When the correlation coefficients for the question types of Level I, the pause time mean, and percentage of teacher talk were compared for the total treatment group and the subsample of each treatment group for the post-test lesson, differences in the strength of the correlation coefficients as well as directional differences for some variables were identified. These data were subjected to one-way analysis of variance to determine if any of the differences were of significance at the .10 level. None were. These correlations are shown in Table 22 in Appendix D.

In deciding whether to reject or not to reject Hypothesis 2, questioning behavior was again analyzed on the basis of the three teaching behaviors used as criterion variables: (1) asking open questions as well as closed questions, (2) pausing, and (3) decreasing the percentage of teacher talk. When the behavior of asking open questions is considered, the evidence available is not sufficient to reject, at the .10 level of significance, this part of Hypothesis 2. When the behavior of pausing is considered, the evidence available was significant at the .10 level for both the total treatment group as well as for the subsample, to reject this part of Hypothesis 2. When the behavior of decreasing teacher talk is considered, the evidence available is at the .10 level of significance, sufficient for rejection of this part of Hypothesis 2.

Hypothesis 2 was therefore rejected for the questioning behaviors of pausing and of decreasing teacher talk. It was not rejected for the behavior of asking open questions as well as closed questions.

Hypothesis 3. The skill developed during the instructional sequence will not transfer to the student teaching experience in the public schools.

Data from the post-test microteaching lessons were compared with data obtained from analysis of the lesson audiotaped during the final week of student teaching for each of the three data-gathering quarters of the study. Only randomly selected fifteen minute segments of the classroom lessons were subjected to analysis to maintain comparability with the fifteen minute microteaching lesson. Seventeen student teachers from the total sample of forty-two were involved in the audiotaping portion of the study. They constituted a stratified random sample because each treatment group was represented.

The data were subjected to correlational analysis and to one-way analysis of variance to test this hypothesis. Information relative to the correlational analyses is presented in Table 10, page 87. This table contains a comparison of the two sets of correlation coefficients (from the post-test data and from the data from the third audiotape). The question types of Level I, pause time mean, and percentage of teacher talk as correlated with the four treatment groups are shown in this table.

When the pairs of correlation coefficients were examined, membership in treatment group R_1 did not correlate at the .10 level of significance with Open Questions. The R_1 members showed a positive relationship with the variable of Pause Time at a level of significance above the .10 level set for the study. The negative relationship of membership in group R_1 and percentage of teacher talk was identified on the third audiotape but the correlation was not at a level of significance. The correlations of membership in group R_1 and Closed Questions changed in direction, from negative to positive. In addition, group R_1 members audiotaped in their student teaching assignments exhibited a negative correlation with Open Questions. None of the correlations were at a level of significance.

The subsample of group R_3 that had been randomly selected for audiotaping purposes had exhibited a positive correlation with Open Questions on the post-test measure. This relationship was maintained during their student teaching and was at a level of significance (.05 level, df=15). Membership in R_3 was also correlated negatively, at a level of significance (.02) with Managerial Questions for the third audiotape. When this subsample was considered, rather than the total R_3 group, membership in R_3 was positively and significantly correlated (.05 level) with the variable of Rhetorical Questions for the post-test lesson. For the third audiotape, the correlation between R_3 and Rhetorical Questions was a negative one although not at a level of significance.

Table 10. Correlation of Question Type, Level I; Pause Time Mean, Teacher Talk for Post-test and Third Audiotape for Subsample by Treatment Group

Variable	R_1	R_2	R_3	R_4
Closed Questions^a	-0.0914	0.1994	-0.2193	0.1431
Closed Questions^b	0.0210	-0.1184	0.1029	-0.0202
Open Questions^a	0.2710	-0.2815	0.1693	-0.2216
Open Questions^b	-0.0620	-0.2110	0.4900*	-0.2305
Managerial Questions^a	0.0875	0.2351	-0.2462	-0.0636
Managerial Questions^b	0.1376	0.3749	-0.5761*	0.0841
Rhetorical Questions^a	-0.3728	-0.1283	0.5066*	0.0287
Rhetorical Questions^b	-0.3387	0.0380	-0.0879	0.4354*
Pause Time^a	0.6319*	-0.2921	-0.0674	-0.3820
Pause Time^b	0.5763*	-0.1522	-0.0762	-0.4363*
Teacher Talk^a	-0.5327*	0.1618	0.2394	0.2153
Teacher Talk^b	-0.2222	0.2196	0.0236	0.0293

[a] Post-test (microteaching lesson)

[b] Third audiotape (recorded during final week of student teaching, randomly selected fifteen minute segment of lesson)

*Significant at .10 level or greater (df = 15)
Critical value at .10 level = .412
.05 level = .482
.02 level = .558
.01 level = .606

There were no significant correlations on either the post-test lesson or the third audiotape between membership in group R_2 and any of the variables under consideration (question types of Level I, pausing, percentage of teacher talk).

Membership in group R_4 did not correlate at a level of significance (.10 or above) with any of these variables on the post-test. Two significant correlations were identified in the third audiotape data: with Rhetorical Questions (significant at the .10 level) and with Pause Time (a significant negative correlation at the .10 level).

Data from the post-test lessons and from the randomly selected fifteen minute segment of the third audiotape were subjected to analysis of variance for one-way design. The results of the analyses of variance for which significant F's were obtained are shown in Table 11, page 90. The remaining analyses of variance for which non-significant F ratios resulted are shown in Appendix D. Only four analyses resulted in F values at, or above, the .10 level of significance.

When the behaviors of each of the treatment group subsamples are considered for purposes of comparison with those of the post-test lessons, several differences are evident. The R_1 subsample of student teachers asked more managerial questions in the classroom where they apparently had more need to use this type of question than in their microteaching lessons, involving peers as students.

The members of the group R_4 subsample asked more closed questions during their microteaching lessons for the post-test than they did in the third lesson audiotaped in their student teaching classrooms.

Although they apparently decreased the percentage of closed questions they used, they increased their use of both managerial and rhetorical questions when working with secondary school students in science classes.

Although the group R_3 subsample had maintained a positive correlation with open questions and the strength of the correlation was at the .05 level of significance for the third audiotape, the increase in the use of open questions was not a significant one when these data were examined using analysis of variance.

When the results of the correlational analysis and of the several one-way analyses of variance are studied, the evidence presented is not sufficient to reject Hypothesis 3 for any of the criterion variables: (1) asking open questions as well as closed questions, (2) pausing, and (3) decreasing the percentage of teacher talk. The members of the subsample of group R_1 did maintain a positive correlation with pause time, at the .02 level of significance, and did maintain a negative (but nonsignificant) correlation with percentage of teacher talk. The F values which resulted from the one-way analyses of variance for these variables were not at a level of significance, however. Therefore, Hypothesis 3 cannot be rejected.

Hypothesis 4. There is no relationship between intelligence and questioning ability.

The correlations between intelligence and the question types of Level I, pause time mean, and percentage of teacher talk are given in

Table 11. One-Way Analyses of Variance by Treatment Group Subsamples, Post-test and Third Audiotape, Which Resulted in Significant Differences

Source of Variation	Sum of Squares	df	Variance Estimate	F
	GROUP R_1: MANAGERIAL QUESTIONS			
Between	1052.25	1	1052.25	8.0925*
Within	1300.28	10	130.02	
Total	2352.53	11		
	GROUP R_4: CLOSED QUESTIONS			
Between	854.49	1	854.49	5.0237**
Within	1020.56	6	170.09	
Total	1875.05	7		
	GROUP R_4: MANAGERIAL QUESTIONS			
Between	833.95	1	833.95	7.2730**
Within	687.98	6	114.66	
Total	1521.93	7		
	GROUP R_4: RHETORICAL QUESTIONS			
Between	85.02	1	85.02	25.6275**
Within	19.90	6	3.32	
Total	104.92	7		

*F = 3.28 at .10 level (df = 1,10)

**F = 3.78 at .10 level (df = 1,6)

Table 12. None of these correlations are at the .10 level of significance. Hypothesis 4, therefore, cannot be rejected.

Hypothesis 5. There is no relationship between sex and questioning ability.

The variable of sex of the student teacher was coded using 1 to indicate male and 2, female. The coded information was then correlated with the other variables involved in the study. Table 12 also contains information concerning the correlation of sex with the question types of Level I, with pause time mean, and with percentage of teacher talk as exhibited during the microteaching lesson of the post-test. None of these correlations are at the .10 level of significance. Hypothesis 5 cannot be rejected, also, on this evidence.

Hypothesis 6. There is no relationship between educational set and questioning ability.

Use of the Educational Set Scale resulted in three scores relative to educational set: a total score, a conceptual score, and a factual score. Each of these scores, for each of the forty-two student teachers involved in the study, was correlated with the other variables. The correlations of the Educational Set Scale scores with the question types of Level I, pause time mean, and percentage of teacher talk is shown in Table 12 on page 93.

Only two types of questions (Closed, Managerial) correlated at a level of significance with all three of the educational set scores. There were no significant correlations with any of the educational set scores (total, conceptual, factual) with Open Questions. Nor were there any significant correlations between Pause Time and any of the educational set scores. The percentage of Teacher Talk did not correlate at a level of significance with any of the educational set scores. On the basis of this evidence, Hypothesis 6 cannot be rejected.

Hypothesis 7. There is no relationship between personality type and questioning ability.

The four continuum scores obtained by the use of the Myers-Briggs Type Indicator were correlated with the question types of Level I, the pause time mean, and the percentage of teacher talk to test this hypothesis. The results of the correlational analysis are shown in Table 12 on the following page.

Only two significant correlations were found. The T-F continuum score correlated positively with Managerial Questions. The S-N continuum score correlated negatively with Teacher Talk.

Upon the basis of this evidence, Hypothesis 7 cannot be rejected.

SUMMARY

Skill in questioning was defined for purposes of this study as being exhibited in the teacher behaviors of (1) asking Open Questions as well as Closed Questions, (2) pausing after asking a question considered to involve more than cognitive-memory thinking operations in order to respond so that students have time to think about their answers, and (3) decreasing the amount of teacher talk involved in the lesson.

Table 12. Correlations* of Various Factors with Questioning Techniques for the Total Group of Student Teachers (N = 42)

Variable	Closed Questions	Open Questions	Managerial Questions	Rhetorical Questions	Pause Time Mean	Teacher Talk
Intelligence[a]	0.205	-0.007	-0.256	0.018	-0.152	0.001
Sex[b]	0.122	-0.113	-0.062	-0.085	-0.019	-0.164
Educational Set:total[c]	0.294*	-0.042	-0.289*	-0.121	-0.233	0.097
Educational Set:conceptual[c]	0.258*	0.006	-0.296*	-0.121	-0.254	0.083
Educational Set:factual[c]	-0.331*	0.116	0.258*	0.112	0.184	-0.112
Continuum score[d]						
E-I	-0.117	0.032	0.155	0.072	0.159	-0.066
S-N	0.024	0.116	-0.026	-0.181	0.010	-0.265*
T-F	0.022	-0.205	0.301*	-0.179	0.144	0.076
J-P	-0.001	0.068	-0.061	0.021	-0.057	-0.136

*Critical value = .257 for .10 level of significance (df = 40)

[a] Otis Quick Scoring Mental Ability Test, Gamma Test, Form Em

[b] Male coded 1; Female coded 2

[c] Educational Set Scale by Siegel and Siegel

[d] Myers-Briggs Type Indicator, Form E

When these three behaviors were used as the critical indicators for the acceptance or rejection of the seven hypotheses involved in the study, these findings resulted.

Hypothesis 1. Skill in questioning as a teaching technique cannot be developed through practice and experiences involved in an instructional sequence.

Teacher Behaviors	Rejected/Not Rejected
Asking Open Questions	Not rejected
Pausing	Rejected
Decreasing percentage of teacher talk	Rejected

Hypothesis 2. There is no effect of treatment (teacher of a microclass, pupil in a microclass, member of a control group) on questioning behavior of a preservice teacher.

Teacher Behaviors	Rejected/Not Rejected
Asking Open Questions	Not rejected
Pausing	Rejected
Decreasing percentage of teacher talk	Rejected

Hypothesis 3. The skill developed during the instructional sequence will not transfer to the student teaching experience in the public schools.

Teacher Behaviors	Rejected/Not Rejected
Asking Open Questions	Not rejected
Pausing	Not rejected
Decreasing percentage of teacher talk	Not rejected

Hypothesis 4. There is no relationship between intelligence and questioning ability.

Teacher Behaviors	Rejected/Not Rejected
Asking Open Questions	Not rejected
Pausing	Not rejected
Decreasing percentage of teacher talk	Not rejected

Hypothesis 5. There is no relationship between sex and questioning ability.

Teacher Behaviors	Rejected/Not Rejected
Asking Open Questions	Not rejected
Pausing	Not rejected
Decreasing percentage of teacher talk	Not rejected

Hypothesis 6. There is no relationship between educational set and questioning ability.

Teacher Behaviors	Rejected/Not Rejected
Asking Open Questions	Not rejected
Pausing	Not rejected
Decreasing percentage of teacher talk	Not rejected

Hypothesis 7. There is no relationship between personality type and questioning ability.

Teacher Behavi	Rejected/Not Rejected
Asking Open Questions	Not rejected
Pausing	Not rejected
Decreasing percentage of teacher talk	Not rejected

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

This chapter consists of four parts: a summary of the study, an interpretation of the findings as they relate to the seven hypotheses involved in the study, conclusions, and recommendations.

SUMMARY

The major problem of the study was to assess the effectiveness of an instructional procedure designed to develop skill in questioning, as a teaching technique, by prospective secondary school science teachers. Two subproblems were (1) to determine if the skill developed during the instructional sequence or procedure would transfer to the student teaching experience, and (2) to determine the possible relationship, if any, of such factors as educational set, personality type, intelligence, sex to an individual's questioning skill.

The study took place over a one calendar year period. Four academic quarters were included in the study: Winter Quarter 1968, Spring Quarter 1969, Autumn Quarter 1969, and Winter Quarter 1969. Winter Quarter 1968 was used for the purposes of a pilot study. During the three following data-gathering quarters, forty-two preservice secondary school science teachers were involved in the study. Each was involved during the quarter in which he enrolled in Education 587.27, Student

Teaching in Secondary Schools: Science, at The Ohio State University. This course is not offered during the summer quarter, accounting for the interval between Spring and Autumn Quarters, 1969.

During each of the data-gathering quarters, the study consisted of two parts. Part One involved gathering data relative to the various factors described in subproblem two and conducting the instructional sequence designed to develop skill in questioning. The second part of the study involved gathering data on the questioning practices of randomly selected student teachers as they operated in the public school classroom to which they had been assigned for student teaching.

The forty-two student teachers varied in their extent of participation in the study, depending upon the treatment group to which they were assigned by random selection. Treatment group R_1 members participated in a pretest designed to determine their questioning behavior prior to student teaching, in the instructional sequence as teachers, and in a post-test designed to determine what benefits, if any, they had derived from the instructional sequence. Group R_2 people participated in the pretest, served as student-evaluators for the R_1 teachers during the instructional sequence, and also participated in the post-test. Those individuals assigned to group R_3 participated in only the pretest and post-test situations. Members of group R_4 participated in the post-test only. A randomly selected subsample from each of the four treatment groups was observed during the student teaching assignment and three lessons were tape recorded for each of these individuals. Recordings were made during the first week each individual was given full responsibility in his student teaching assignment, at the midpoint in the quarter, and during the final week of student teaching. A fifteen minute microteaching lesson was used to provide the teachers an opportunity to practice their questioning techniques during the instructional sequence. Therefore, a fifteen minute segment of each of the classroom lessons was randomly selected for analysis in the study to maintain comparability in time.

The three criterion variables involved in the study were (1) the ability to ask Open Questions (those having a wide range of acceptable responses) as well as Closed Questions (those having a limited number of acceptable responses), (2) pausing after asking a question to provide students with time to think before responding, and (3) decreasing the percentage of teacher talk taking place during a lesson.

The questions identified from the videotaped microteaching lessons of the post-test and from the audiotapes were transcribed and made into typescripts. Using these typescripts and viewing the videotapes, three judges trained in the Question Category System developed as a part of this study classified the teacher's questions according to the levels of the Question Category System. The investigator followed a similar procedure in the analysis of the audiotapes. These data were used in determining if the criterion variable of asking Open Questions had been exhibited at a level of significance (.10). The length of the teacher's pause after each question was measured with the use of a timing device indicating seconds and the mean pause time for each teacher for the posttest lessons and for the fifteen minute segments of the classroom lessons was determined. The verbal interaction was also timed and the percentage of teacher talk heard during the fifteen minute lesson was also determined for each of the tapes analyzed. These data were applied to the second and third criterion variables: pausing and decreasing the percentage of teacher talk.

The interpretation of the data analyses will be considered in the following section of this chapter.

INTERPRETATION OF RESULTS

Hypotheses 1 and 2

Hypotheses 1 and 2 will be discussed together because they are so closely related. Hypothesis 1 is the statement that Skill in questioning as a teaching technique cannot be developed through practice and experiences involved in an instructional sequence, while Hypothesis 2 is There is no effect of treatment (teacher of a microclass, pupil in a microclass, member of a control group) on the behavior of a preservice teacher.

Each of these, and subsequent hypotheses, was considered with respect to the three criterion variables described earlier in this chapter as well as in Chapter 4: (1) asking Open Questions, (2) pausing, (3) decreasing the percentage of teacher talk.

When the post-test data acquired for the three data-gathering quarters of the study were analyzed, those individuals who had been members of treatment group R_1 were shown to exhibit a positive correlation with the variable of Open Questions. This correlation was not at the .10 level of significance, however. Membership in treatment group R_1 also correlates positively with the variable of Pause Time and negatively with the variable of percentage of Teacher Talk, with both correlations exceeding the critical value for .01 level of significance.

None of the other treatment groups (R_2, R_3, R_4) indicate any significant positive correlations with the four question categories of Level I of the Question Category System. All three groups (R_2, R_3, R_4) show a negative (nonsignificant) correlation with the variable of Open Questions as well as with the variable of Pause Time. Groups R_2, R_3, and R_4 all correlate positively, at a nonsignificant level, with the variable of percentage of Teacher Talk.

Apparently the experiences included in the instructional sequence were effective for enabling the members of group R_1 to acquire the behaviors of pausing after asking a question and of questioning and handling responses in a manner designed to decrease the amount of talking which they as teachers did during the microteaching lesson.

Serving as pupils for the microteaching lessons and evaluating the teacher's performance at the end of each lesson had no apparent beneficial effect on the members of group R_2 as indicated by the lack of significant correlations with the criterion variables. It is possible that the experience of being student-evaluators was not sufficient to enable these individuals to gain insight into the questioning skills being stressed in the instructional sequence without the opportunity to practice these behaviors.

Data concerning groups R_3 and R_4 were also examined. Neither of these groups exhibited any significant correlations with any of the question types of Level I, with Pause Time, or with Teacher Talk although the direction of the correlations for each group were the same for each of these variables. These findings might be used to infer that the experience of being videotaped and then viewing one's teaching performance before reteaching the same lesson after a four week interval did not result in any significant changes in teaching performance.

When the behaviors relative to the three criterion variables are considered, it is apparent that student teachers acquire with less difficulty, during the limited time of the instructional sequence, the behaviors of pausing and of decreasing the percentage of teacher talk. This finding does not hold true for the behavior of asking Open Questions.

Open Questions are defined, for the purposes of this study, as those for which there is a wider range of acceptable responses than is possible for Closed Questions. At Level II of the Question Category System, the category of Open Questions is subdivided into Divergent Thinking Questions and Evaluative Questions. Although the scope of analysis for testing the hypotheses involved in this study was limited to Level I of the Question Category System, questions identified in the lessons were categorized at all three levels. The findings for Levels II and III will not be detailed in this chapter, however. Some of the investigators (Hunter, Kleinman, Moyer) cited in this Chapter 2 have reported few, or no, value questions in the lessons they observed. In this study, when Open Questions were examined at Level II, the following findings resulted. Two of the nine individuals (22%) of the R_2 group asked Evaluative Thinking Questions. Two of twelve people (16%) in group R_3 asked questions classified as Evaluative Thinking. One of ten (10%) of the R_4 student teachers asked Evaluative Thinking Questions. In group R_1 five of eleven people (45%) asked questions categorized as Evaluative Thinking.

The percentage which these Evaluative Thinking Questions constituted of the total number of questions asked by each individual is shown in Table 20 in Appendix D. When these data and other information relative to Open Questions are considered, it is important to remember that the student teachers were asked to use the same topic for their posttest lessons as they had chosen to teach for the pretest. A number of the individuals who were members of group R_1 had chosen topics that did not lend themselves to Open Questions but rather involved cognitive-memory and convergent thinking operations on the part of the students.

It seems logical to infer that the choice of the lesson topic as well as the duration of the instructional sequence were factors influencing the development of the behavior of asking Open Questions, at least in so far as the subjects involved in this study were concerned.

Hypothesis 3

In this hypothesis is postulated that The skill developed during the instructional sequence will not transfer to the student teaching experience in the public schools.

This hypothesis could not be rejected, on the basis of the available evidence, for any of the criterion variables. When the data were examined, group R_1 was found to have maintained a positive correlation with the variable of Pause Time. This correlation was above the .10 level of significance set for the study. The correlation between membership in group R_1 and percentage of teacher talk was a negative one but not at a level of significance (.10 or greater.) The correlation between group R_1 membership and Open Questions was a negative one, not significant at the .10 level, when data obtained from the lesson recorded during the final week of student teaching were considered.

When the results of the one-way analyses of variance were studied, no significant differences at the .10 level of significance were identified for any of the treatment groups on the three criterion variables: asking Open Questions, pausing, and decreasing the percentage of teacher talk.

Apparently the participants in the instructional sequence (group R_1 members) were able to continue pausing and to decrease the percentage of the time they talked in the classroom but not to the extent that these behaviors were significant (.10 level).

Changes occurred in the behaviors of the subsamples of groups R_2, R_3, and R_4, as indicated in the tables and discussion found in Chapter 4 of this study. Discussion is restricted here to the group R_1 and R_2 subsamples since only these individuals participated in the instructional sequence.

There were no significant correlations of membership in group R_2 with any of the question types of Level I, with Pause Time, and with percentage of Teacher Talk. As previously stated, membership in group R_1 correlated at or above the .10 level of significance only with the variable of Pause Time. This was not a significant finding when tested by one-way analysis of variance, probably due to sample size (N = 6).

Several factors need to be examined when the results relative to Hypothesis 3 are considered. One, the taping was done during the final week of the student teaching assignment. This time coincided with the approaching end of the public school year. Nine of the seventeen lessons involved review as a primary activity during the class period. Five of the six lessons recorded for the group R_1 subsample emphasized review activities. The time at which the final recording was done was an inopportune one if the R_1 individuals were expected to have an opportunity to choose a lesson topic that enabled them to ask Open Questions.

In addition the influence of the cooperating teacher needs to be considered. The investigator worked closely with the members of group R_1 for a four to five week period of time early in the student teaching quarter. The amount of time involved was approximately six to seven hours for each member of R_1. The cooperating teacher worked daily with these people for the entire student teaching assignment. The investigator did serve as the college supervisor for group R_1 student teachers for the second and third data-gathering quarters of the study. This extended the contact to five to seven visits to the classrooms of the student teachers and to conferences following these visits but the amount of contact was not comparable to that of the cooperating teacher.

One might postulate that a "survival syndrome" exists in student teaching. This might be categorized as behaving in the manner, as a student teacher, that is suggested or stated by the cooperating teacher as being the desirable way to conduct a class. If the cooperating teacher considers as a primary objective that of covering a large body of content and exposing the pupils to a large fund of factual information, the student teacher is not likely to depart from this model in order to practice asking Open Questions which emphasize thinking operations other than cognitive-memory and convergent thinking. Student teachers can, however, continue the behaviors of pausing and of decreasing the percentage of teacher talk without deviating from the cooperating teacher's goals of science teaching.

A third factor that should be considered is that the student teachers worked with peers as pupils during the microteaching lessons. In such situations they were less concerned with classroom management problems than they were while doing their student teaching. The change in pupil population may be assumed to have influenced the increased use of Managerial Questions in public school science classes when post-test and third audiotape data for group R_1 student teachers were compared.

Hypothesis 4

The hypothesis that There is no relationship between intelligence and questioning ability could not be rejected for any of the criterion variables of this study. The range of intelligence scores on the Otis Quick Scoring Mental Ability Test used in this study was not a wide one.

In order to enter the Professional Division of The College of Education students must have a 2.25 point average (A = 4 points), both in their general undergraduate courses and in their science content area. This would seem to reduce any wide variations in intelligence scores.

Hypothesis 5

This hypothesis, There is no relationship between sex and questioning ability, also could not be rejected for any of the criterion variables. One might infer that prospective science teachers formulate questions on the basis of the content and objectives of the lesson during which the questions will be used rather than on the basis of the sex of the teacher.

Hypothesis 6

This was stated as There is no relationship between educational set and questioning ability. Three scores were obtained from the Educational Set Scale used to derive information relative to this hypothesis: a total score, a conceptual score, and a factual score. All three scores correlated, at or above the .10 level of significance, with the variables of Closed Questions and Managerial Questions (see Table 12, page 93). The total and conceptual scores correlated positively with Closed Questions and negatively with Managerial Questions. It had been hypothesized, prior to beginning data collection, that the conceptual scores would correlate positively with Open Questions and that factual scores would correlate negatively with this same variable. Results proved otherwise. Both conceptual and factual scores correlated positively with Open Questions although neither correlation was at the .10 level of significance. In addition, the positive and significant correlation of the conceptual score of the Educational Set Scale with Closed Questions was a most unexpected finding.

No satisfactory explanation for this finding has yet been developed. The Educational Set Scale test questions ask the respondents to indicate topics they would most like to study, would be least interested in studying, or which they consider of neutral value with respect to interest in studying. That there may be a lack of relationship between the type of topics (conceptual, factual) one would like to pursue as a student and the types of questions one asks as a teacher is a possibility but it does not appear to be a promising one.

Hypothesis 7

This is stated as There is no relationship between personality type and questioning ability. Data relative to this hypothesis were obtained through the use of the Myers-Briggs Type Indicator, Form E. Only two continuum scores, those of Thinking-Feeling (T-F) and of Sensing-Intuition (S-N), exhibited correlations at the .10 level of significance. The T-F continuum score correlated positively with the variable of Managerial Questions. The S-N continuum score correlated negatively, at the .10 level of significance, with the variable of Teacher Talk. None of the continuum scores correlated at the .10 level of significance with membership in any of the treatment groups (see Table 17, Appendix D).

On the basis of the evidence obtained in this study, this hypothesis could not be rejected for any of the criterion variables. Apparently, for the individuals involved in this study, their preferred mode of operation as described by the eight personality factors (extroversion-intraversion, sensing-intuition, thinking-feeling, judgment-perception) did not significantly influence their questioning techniques.

CONCLUSIONS

Generalizations involving the results of this study are limited by the characteristics of the population sampled and by the accuracy of the interpretations of the data obtained.

This group appears representative of the population of prospective secondary school science teachers enrolled at The Ohio State University. Questioning, therefore, appears to be a skill that can be developed, through instruction and practice, by the individuals comprising this population. The development of questioning skill does not appear to be limited by intelligence, sex, personality type, or educational set, in so far as this sample is concerned.

The skill of effective questioning as exemplified by the teacher behaviors of asking Open Questions, pausing, and decreasing the percentage of teacher talk should be considered as it relates to lesson topic, type of student population, and length of time allotted for skill development. Knowing how to formulate Open Questions is of little value if the teacher is unable to select a lesson topic in which he has the opportunity to use these questions to stimulate the thinking of his students. Being able to use Open Questions in teaching situations in which peers serve as students does not imply that a student teacher will also be able to use Open Questions when teaching secondary school pupils. Skill development is not an activity that reaches a high degree of mastery in a limited period of time. It appears that skill in questioning, like other skills, requires an extended amount of practice before a significant degree of mastery is attained.

RECOMMENDATIONS

Recommendations relative to this study will be considered in two groups: those relating to further research and those relating to educational practice. Recommendations relative to educational practice are grouped with respect to their implications for teacher educators, for supervisory personnel in the public schools, and for classroom teachers.

For Further Research

Earlier in the discussion contained in this chapter the inference was drawn that the length of time involved in the instructional sequence was insufficient to provide for skill development at a level sufficient to transfer from the microteaching situation to the public school classroom. The accuracy of this inference needs to be tested by further research.

The student teachers who had participated as teachers in the instructional sequence worked with peers as pupils. This study might be replicated using secondary school students for the microteaching lessons to determine what changes, if any, might result when the age, experiential background, and behaviors of the pupils of the microteaching lessons paralleled those of the pupils with whom the preservice teachers worked as a part of their student teaching assignment.

In this study, the instructional sequence took place during the same quarter as student teaching. A study might be conducted to determine what changes might result if the instructional sequence were to be conducted prior to the quarter in which the preservice teacher enrolls for student teaching. The time for the instructional sequence, as well as the length of time involved in the instructional sequence, might be varied for different groups of preservice teachers to determine at which point in their undergraduate career such an experience would result in maximum benefits in developing questioning skill.

If a similar study were to be conducted, the instructional sequence might be modified to include more emphasis upon choosing lesson topics and activities that promote the use of Open Questions to determine if such a change would result in the exhibition of the behavior of asking Open Questions at a level of significance (.10 or greater).

No attempt was made in this study to analyze student responses to the questions identified in the lessons. Such an investigation should be conducted to determine how many and what kinds of questions receive responses and how well the student responses match the teacher's questions.

An additional study might be conducted to determine if teachers discriminate in their use of pause time. Do they pause longer in waiting for a response to an Evaluative Thinking Question than they do when they ask a Convergent Thinking Question or do they fail to discriminate? Length and quality or adequacy of student responses might be investigated in relation to the length of the pause which follows the question.

The findings of this study with respect to the scores of the Educational Set Scale and their correlation with the question types of Level I are not easily explained and appear to merit further investigation. This test appears to deserve further analysis to determine whether it validly measures conceptual thinking.

The individuals involved in this study were preservice teachers. A similar study might be conducted with inservice teachers to determine if experience or confidence in the role of teacher has any effect on the development of questioning skill.

Studies might be conducted to determine the effect of the curriculum content on the opportunity to use Open Questions in science classes. It was inferred from this study that certain topics did not provide opportunities to use Open Questions. Is it possible that some of the newer courses of study in secondary school science that are considered to be inquiry-oriented are really more structured and content-centered that their developers consider them to be?

For Educational Practice

This study appears to have implications for (1) teacher educators, (2) supervisory personnel in the public schools, and (3) classroom teachers.

(1) Teacher educators should become aware that preservice teachers can develop teaching skills, given sufficient guidance and provided with opportunities to practice the skill. Questioning appears to be only one example of a teaching behavior that customarily is handled as if an individual either did or did not possess it before deciding to become a teacher. It is true that some individuals do possess some degree of skill in questioning prior to formal instruction. It is also true, however, that their level of proficiency in the skill can be increased through conscious attention to development of the skill.

Teacher educators should guard against developing skill in questioning apart from the context in which this skill will be used. This implies doing more than verbalizing about the desirability of acquiring the skill. It implies becoming aware of the types of activities, lesson objectives, and content that lend themselves to the use of this skill as well as the development of some amount of perception concerning the ways in which the use of this skill will promote learning on the part of the public school students with whom the teacher works. In addition it implies providing opportunities in which preservice teachers can work with public school pupils in nonthreatening situations before being asked to display the behavior as a student teacher.

(2) Supervisory personnel (principals, science supervisors, department chairmen) should become aware of the fact that if science teachers are to promote the development of students who become independent investigators, classroom teachers must be provided with a curriculum and materials that provide them with opportunities to do more than cover a

large amount of factual information. Supervisory personnel need to encourage their teachers to analyze their teaching behavior and to evaluate the kinds of questions they emphasize in their science lessons. This needs to be done in a manner so that the teachers are encouraged to be critical in their self-analysis without feeling threatened or insecure.

Inservice programs need to be developed in which teaching behaviors are emphasized. In the past the primary objective of most inservice programs in science education has been to introduce teachers to new content and materials. Less emphasized has been the development of teaching methods which promote the most effective use of the newer, investigative type of science program. Teachers who lecture to students enrolled in an inquiry-oriented science course seem to have missed some part of the rationale of the program. Perhaps they need guidance in translating the activities into action with students so that they achieve the intended goals of course of study.

(3) Classroom teachers need to become aware of the types of questions they customarily ask. They need to analyze their teaching behavior and to critically evaluate their lesson plans and objectives as well as their implementation of these plans and objectives in the classroom. They need to preplan key questions to use, if possible, during the course of the class period and to become aware of the general pattern of student response and teacher reinforcement they use while teaching. Many teachers do ask many questions during a lesson. The majority of of these questions may never involve any thinking operations that go

beyond the level of factual-recall. Not only are the students not being encouraged to analyze or synthesize or infer, to cite some other levels of thinking, they are also being encouraged to depend upon the teacher as the authority who decides whether or not a response is correct.

Classroom teachers can work with supervisory personnel to develop checklists or other tools to use in self-evaluative activities. If they do not feel that they can conduct a class and also monitor their teaching behavior simultaneously, they can tape record their class sessions for later evaluation. If they accept as their primary responsibility as teachers the development of students who become independent learners, they need to set an example for their students to follow.

APPENDIX A

BMD BIOMEDICAL COMPUTER PROGRAMS USED IN THE STUDY

BMD BIOMEDICAL COMPUTER PROGRAMS*

01D: Simple Data Description output includes:
- (1) Means
- (2) Standard deviations
- (3) Standard errors of means
- (4) Maximum values
- (5) Minimum values
- (6) Ranges
- (7) Sample sizes

02D: Correlation with Transgeneration output includes:
- (1) Sums
- (2) Means
- (3) Cross-product deviations
- (4) Standard deviations
- (5) Variance-covariance matrix
- (6) Correlation matrix

02R: Stepwise Regression output includes:
- (1) Multiple R
- (2) Standard error of estimate
- (3) Analysis-of-variance table
- (4) For variables in the equation:
  - (a) Regression coefficient
  - (b) Standard error
  - (c) F to remove
- (5) For variables not in the equation:
  - (a) Tolerance
  - (b) Partial correlation coefficient
  - (c) F to enter

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*BMD Biomedical Computer Programs, W. J. Dixon, editor. (University of California Publications in Automatic Computation No. 2. Berkeley: University of California Press, 1968)

01V: Analysis of Variance for One-Way Design output includes:
(1) Optional listing of the group or treatment means and standard deviations
(2) An analysis-of-variance table including:
(a) Within groups, between groups, and total sums of squares
(b) Within groups, between groups, and total degrees of freedom
(c) Within groups and between groups mean squares
(d) F ratio (for $H_0:\mu_1 \; . \; . \; . =\mu_k$).

02V: Analysis of Variance for Factorial Design output includes:
(1) Analysis-of-variance table and the grand mean
(2) A breakdown of the sums of squares into orthogonal polynomial components for as many as four main effects and all of their first order interactions.
(3) Main effects and first order interactions for the variables specified in (2).
(4) Cell and marginal means.

APPENDIX B

WRITTEN INSTRUMENTS USED IN THE STUDY

WRITTEN INSTRUMENTS USED IN THE STUDY

Educational Set Scale

This is a ninety-three item test, developed by Laurence and Lila Siegel, as a part of a research project entitled "A Study of the Instructional Gestalt in University Courses Presented by Television" (74). The Siegels believe their instrument measures a version of cognitive style: a set presumed to determine the specific kind of content the learner tends to extrapolate from his various educational experiences (74:41-42).

The items are grouped in triads. Respondents are asked to rank each of the items in the triad according to interest as possible topics for study. A rank of 1 indicates the topic of most interest; of 2, of intermediate interest; of 3, of least interest. Ranking is done on a forced-choice basis. No ranks may be omitted nor may two items be assigned the same rank.

Two estimates of reliability have been obtained for the Educational Set Scale. The split-half (odd-even) reliability corrected for length in a sample of 200 respondents was .94. An estimate of retest reliability (involving sixty-six students) was .92 for time intervals ranging between one and five days (73:6).

Myers-Briggs Type Indicator

According to this instrument's developer, the purpose of the Myers-Briggs Type Indicator is to implement Jung's theory of type (61:1). The form (Form E) used in this study contains 109 items containing paired statements. (One item has three alternatives.) Respondents are asked to mark which one of the paired statements best describes themselves. An item may be left blank if the respondent is unable to choose between the alternatives or does not think either is appropriate.

Scoring results in four preference scores, one for each of the personality indices. These indices are

Index	Preference as between	Affects individual's choice as to
EI	Extroversion or Intraversion	Whether to direct perception and judgment upon the environment or world of ideas
SN	Sensing or Intuition	Which of these two kinds of perception to rely upon
TF	Thinking or Feeling	Which of these two kinds of judgment to rely upon
JP	Judgment or Perception	Whether to use judging or perceptive attitude for dealing with environment (61:1)

Further details are found in the manual (61:51-64).

The statement that the Indicator is based on Jungian concepts has been argued (99:322, 187:70). Nevertheless, findings exist which indicate that type scores relate meaningfully to a wide range of variables including personality, interest, value, aptitude and performance measures, academic choice, and behavior ratings (99:322).

Reliability for this instrument was investigated by using the logically split-half procedure on various levels. The split-half reliability of the personality type indices for a sample of 100 college students was .82 for EI, .87 for SN, .83 for TF, .84 for JP. Split-half reliabilities from type categories, computed by applying the Spearman-Brown Prophecy Formula to Phi coefficients, were computed for samples which included 100 college males and 100 college females. For males, the figures were .55 for EI, .73 for SN, .75 for TF, .58 for JP. For the females, .65 for EI, .64 for SN, .67 for TF, .68 for JP. These same two groups were included in the samples for which the split-half reliabilities for type categories were computed by applying the Spearman-Brown Prophecy Formula to Tetachoric r. These results were: for males, .74 for EI, .88 for SN, .90 for TF, .76 for JP; for females, .81 for EI, .83 for SN, .84 for TF, .84 for JP (61:20).

The validity of the Indicator is discussed, in the manual, in terms of the way in which it correlates with other instruments such as the Strong Vocational Interest Blank, the Allport-Vernon-Lindzey Study of Values, Edwards Personal Preference Scale, and the Personality Research Inventory (61:21-26).

Otis Quick-Scoring Mental Ability Test

This is an eighty item test designed to provide an indication of mental ability. It has been used and modified for many years (first copyright date, 1939). Form Em of the Gamma Test of the Otis instrument has a corrected split-half reliability coefficient of .88, based on administration to 489 college freshmen in 1953. Difficulty and validity indices for each item of the Forms Em and Fm were computed also. The mean validity index of the test items in each form was approximately .50 (64). LeFever (99:480-481) criticized the information furnished the test-consumer as being both antiquated and inadequate. Nevertheless, because the test scores were not going to be used for placement or diagnostic purposes, the Otis Quick-Scoring Mental Ability Test was used in the study to provide an indication of mental ability.

APPENDIX C

DESCRIPTION OF THE SAMPLE BY QUARTERS

TABLE 13

MEANS AND STANDARD DEVIATIONS OF STUDENT TEACHER VARIABLES AS DISTRIBUTED FOR EACH OF THE THREE DATA GATHERING QUARTERS

	Total Sample (N=42)		Spring 1969 (N=17)		Autumn 1969 (N=13)		Winter 1969 (N=12)	
Variable	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Intelligence[a]	124.36	7.78	123.23	8.20	124.77	7.48	125.50	7.94
Educational Set[b] Score:total	27.12	11.28	31.24	10.84	23.77	12.20	24.92	9.83
Educational Set Score:conceptual	35.26	7.15	38.29	7.14	33.38	7.12	33.00	6.08
Educational Set Score:factual	8.14	4.45	7.05	3.94	9.62	5.35	8.08	3.96
Continuum Scores[c]								
E-I	92.21	23.24	93.71	23.61	101.85	21.55	79.67	20.26
S-N	110.95	26.71	121.12	23.48	108.69	25.02	99.00	29.21
T-F	92.95	21.28	92.41	19.78	90.54	20.93	96.33	24.93
J-P	106.24	28.37	113.82	25.27	109.31	30.55	92.17	27.16
Extroversion[c]	14.50	6.56	13.71	6.74	12.85	6.39	17.42	6.02
Intraversion	9.98	6.13	10.18	5.91	12.46	6.45	7.00	5.20
Sensing	8.05	7.42	5.71	6.73	8.54	5.98	10.83	9.12
Intuition	13.93	6.45	15.76	6.30	15.31	5.63	9.83	6.09
Thinking	10.83	5.78	11.12	6.08	11.46	5.27	9.75	6.21
Feeling	7.62	5.47	7.47	4.99	7.31	5.12	8.17	6.79
Judgment	11.40	6.71	10.06	5.82	10.23	7.21	14.58	6.79
Perception	14.21	7.43	16.47	6.99	14.38	8.30	10.83	6.26
Sex[d]	1.26	0.44	1.29	0.47	1.31	0.48	1.17	0.39

TABLE 13--Continued

Variable	Total Sample (N=42) Mean	S.D.	Spring 1969 (N=17) Mean	S.D.	Autumn 1969 (N=13) Mean	S.D.	Winter 1969 (N=12) Mean	S.D.
Student teaching[e]								
Biology	1.33	0.48	1.53	0.51	1.38	0.51	1.00	0.0
Chemistry	1.12	0.33	1.00	0.0	1.23	0.44	1.17	0.39
Earth Science	1.24	0.43	1.35	0.49	1.08	0.28	1.25	0.45
Physics	1.07	0.26	1.06	0.24	1.00	0.0	1.17	0.39
General Science	1.24	0.43	1.06	0.24	1.31	0.48	1.42	0.51
School Level[f]	1.52	0.51	1.59	0.51	1.62	0.51	1.33	0.49

[a] Otis Quick Scoring Mental Ability Test, Gamma Test, Form Em

[b] Educational Set Scale by Siegel and Siegel

[c] Myers-Briggs Type Indicator, Form E

[d] Male = 1; Female = 2

[e] No = 1; Yes = 2

[f] Junior high school = 1; Senior high school = 2

APPENDIX D

STATISTICAL TABLES

TABLE 14

REGRESSION ANALYSES USING THE STUDENT TEACHER VARIABLES AND SELECTED QUESTIONING TECHNIQUE VARIABLES AS INDEPENDENT PREDICTOR VARIABLES FOR QUESTION TYPES, LEVELS I AND II, PAUSE TIME, TEACHER TALK, POST-TEST LESSON

Independent Variable	Multiple R	Multiple R^2	Increase in Multiple R^2	df	F
		CLOSED QUESTIONS			
Educational Set Scale:factual	0.3313	0.1098	0.1098	1/40	4.9318
		OPEN QUESTIONS			
Teacher talk	0.5016	0.2516	0.2516	1/40	13.4491
Student teaching: earth science	0.5477	0.3000	0.0483	2/39	2.6934
		MANAGERIAL QUESTIONS			
Student teaching: general science	0.4765	0.2271	0.2271	1/40	11.7530
Student teaching: biology	0.5727	0.3280	0.1009	2/39	5.8569
Pause time	0.6358	0.4042	0.0762	3/38	4.8590
Educational Set Score:factual	0.6676	0.4457	0.0415	4/37	2.7722
Feeling	0.6942	0.4820	0.0362	5/36	2.5172
		RHETORICAL QUESTIONS			
Student teaching: physics	0.4327	0.1873	0.1873	1/40	9.2162
Group R_3	0.5304	0.2813	0.0940	2/39	5.1030
		COGNITIVE-MEMORY QUESTIONS			
None					

TABLE 14--Continued

Independent Variable	Multiple R	Multiple R^2	Increase in Multiple R^2	df	F
		CONVERGENT THINKING QUESTIONS			
Educational Set Score:factual	0.3418	0.1169	0.1169	1/40	5.2930
Student teaching: chemistry	0.4807	0.2311	0.1142	2/39	5.7942
Group R_2	0.5459	0.2980	0.0669	3/38	3.6193
Feeling	0.6009	0.3610	0.0631	4/37	3.6515
Intraversion	0.6434	0.4140	0.0530	5/36	3.2549
		DIVERGENT THINKING QUESTIONS			
Teacher talk	0.4127	0.1704	0.1704	1/40	8.2133
Group R_2	0.4887	0.2389	0.0685	2/39	3.5100
Student teaching: general science	0.5498	0.3023	0.0635	3/38	3.4566
		EVALUATIVE THINKING QUESTIONS			
Teacher talk	0.3285	0.1079	0.1079	1/40	4.8389
		PAUSE TIME (MEAN)			
Group R_1	0.5348	0.2860	0.2860	1/40	16.0231
Student teaching: physics	0.6193	0.3836	0.0976	2/39	6.1721
Student teaching: chemistry	0.6591	0.4344	0.0509	3/38	3.4167
Teacher talk	0.6934	0.4808	0.0464	4/37	3.3084
E-I continuum score	0.7201	0.5185	0.0377	5/36	2.8175
		TEACHER TALK			
Closed Questions	0.5016	0.2516	0.2516	1/40	13.4491
Group R_1	0.6376	0.4066	0.1550	2/39	10.1843
Sex	0.6883	0.4738	0.0672	3/38	4.8507
Convergent Thinking Questions	0.7168	0.5138	0.0400	4/37	3.0451
Student teaching: chemistry	0.7405	0.5483	0.0346	5/36	2.7542

TABLE 15

STUDENT TEACHER VARIABLES AND QUESTIONING TECHNIQUE VARIABLES RESULTING IN CORRELATIONS AT THE .10 LEVEL OF SIGNIFICANCE OR GREATER WITH QUESTION TYPES, LEVEL I, POST-TEST LESSON

Variable	Correlation Coefficient
CLOSED QUESTIONS	
Open Questions	-0.563
Managerial Questions	-0.553
Rhetorical Questions	-0.410
Cognitive-Memory Questions	0.655
Convergent Thinking Questions	0.421
Divergent Thinking Questions	-0.533
Evaluative Thinking Questions	-0.343
Educational Set Scale: total score	0.294
Educational Set Scale: conceptual score	0.258
Educational Set Scale: factual score	-0.331
OPEN QUESTIONS	
Cognitive-Memory Questions	-0.349
Convergent Thinking Questions	-0.287
Divergent Thinking Questions	0.811
Evaluative Thinking Questions	0.737
Student teaching: biology	0.279
Teacher talk	-0.502
MANAGERIAL QUESTIONS	
Cognitive-Memory Questions	-0.345
Convergent Thinking Questions	-0.268
Educational Set Scale: total score	-0.289
Educational Set Scale: conceptual score	-0.296
Educational Set Scale: factual score	0.258
T-F continuum score	0.301
Thinking	-0.291
Feeling	0.290
Student teaching: earth science	0.267
Student teaching: physics	0.280
Student teaching: general science	-0.477
Pause time mean	0.356

TABLE 15--Continued

Variable	Correlation Coefficient
RHETORICAL QUESTIONS	
Cognitive-Memory Questions	-0.258
Student teaching: physics	0.433
Treatment group R_1	-0.370
Teacher talk	0.354

TABLE 16

VARIABLES THAT CORRELATE AT THE .10 LEVEL (OR GREATER) OF SIGNIFICANCE WITH PAUSE TIME MEAN, TEACHER TALK, POST-TEST LESSON

Variable	Correlation Coefficient
PAUSE TIME MEAN	
Managerial Questions	0.356
Treatment group R_1	0.535
PERCENTAGE OF TEACHER TALK	
Open Questions	-0.502
Rhetorical Questions	0.354
Divergent Thinking Questions	-0.413
Evaluative Thinking Questions	-0.329
S-N continuum score	-0.265
Sensing	0.270
Intuition	-0.369
Student teaching: biology	-0.366
Student teaching: physics	0.283
Treatment group R_1	-0.477

TABLE 17

VARIABLES THAT CORRELATE AT THE .10 LEVEL (OR GREATER) OF SIGNIFICANCE WITH TREATMENT GROUP MEMBERSHIP, POST-TEST LESSON

Variable	Correlation Coefficient
TREATMENT GROUP R_1	
Rhetorical Questions	-0.370
Pause time mean	0.535
Thinking	-0.277
Teacher talk	-0.477
TREATMENT GROUP R_2	
Convergent Thinking Questions	0.284
Divergent Thinking Questions	-0.292
Educational Set Scale: total score	0.296
Educational Set Scale: conceptual score	0.285
Educational Set Scale: factual score	-0.294
TREATMENT GROUP R_3	
Student teaching: general science	0.265
TREATMENT GROUP R_4	
Educational Set Scale: factual score	0.287
Student teaching: physics	0.297

VARIABLES LISTED IN TABLE 18

1. Closed Questions
2. Open Questions
3. Managerial Questions
4. Rhetorical Questions
5. Cognitive-Memory Questions
6. Convergent Thinking Questions
7. Divergent Thinking Questions
8. Evaluative Thinking Questions
9. Otis Intelligence Score
10. ESS total score
11. ESS conceptual score
12. ESS factual score
13. E-I continuum score
14. S-N continuum score
15. T-F continuum score
16. J-P continuum score
17. Extroversion score
18. Intraversion score
19. Sensing score
20. Intuition score
21. Thinking score
22. Feeling score
23. Judgment score
24. Perception score
25. Sex
26. Student teaching:biology
27. Student teaching:chemistry
28. Student teaching:earth science
29. Student teaching:physics
30. Student teaching:general science
31. School level
32. Treatment group R_1
33. Treatment group R_2
34. Treatment group R_3
35. Treatment group R_4
36. Pause time mean score
37. Percentage of teacher talk

TABLE 18
CORRELATION COEFFICIENTS FOR TOTAL VARIABLES INVOLVED IN THE STUDY

	COL. 1	COL. 2	COL. 3	COL. 4	COL. 5	COL. 6	COL. 7	COL. 8
1	1.0000	-0.5631	-0.5529	-0.4101	0.6551	0.4212	-0.5332	-0.3435
2	-0.5631	1.0000	-0.2223	-0.0884	-0.3488	-0.2868	0.8106	0.7371
3	-0.5529	-0.2223	1.0000	0.1687	-0.3450	-0.2681	-0.1581	-0.1536
4	-0.4101	-0.0884	0.1687	1.0000	-0.2576	-0.1036	0.0655	-0.2277
5	0.6551	-0.3488	-0.3450	-0.2576	1.0000	-0.3529	-0.3056	-0.2340
6	0.4212	-0.2868	-0.2681	-0.1036	-0.3529	1.0000	-0.3326	-0.1169
7	-0.5332	0.8106	-0.1581	0.0655	-0.3056	-0.3326	1.0000	0.2219
8	-0.3435	0.7371	-0.1536	-0.2277	-0.2340	-0.1169	0.2219	1.0000
9	0.2046	-0.0073	-0.2560	0.0175	0.1309	0.1907	-0.0890	0.0802
10	0.2942	-0.0423	-0.2891	-0.1208	0.1078	0.2376	-0.1133	0.0947
11	0.2581	0.0055	-0.2956	-0.1208	0.1384	0.1621	-0.0486	0.0964
12	-0.3313	0.1159	0.2581	0.1123	-0.0511	-0.3418	0.2091	-0.0852
13	-0.1166	0.0323	0.1553	0.0722	-0.0576	-0.1681	-0.0492	0.1265
14	0.0244	0.1159	-0.0262	-0.1808	-0.0425	0.0749	0.1026	0.0747
15	0.0217	-0.2050	0.3012	-0.1791	0.1584	-0.1216	-0.1384	-0.1944
16	-0.0009	0.0676	-0.0611	0.0213	-0.1606	0.1554	0.1434	-0.0830
17	-0.0164	0.0967	-0.0988	-0.0474	-0.0029	0.0813	0.1161	0.0429
18	-0.1933	-0.0017	0.2546	0.1264	-0.0892	-0.1982	-0.0458	0.0915
19	-0.1715	0.0174	0.0590	0.1908	0.0747	-0.2650	0.0675	-0.0162
20	-0.0198	0.2431	-0.1687	-0.0849	-0.0700	0.0882	0.1842	0.1793
21	-0.0338	0.1942	-0.2906	0.1520	-0.1220	0.0477	0.1496	0.1765
22	-0.0037	-0.1966	0.2895	-0.1571	0.1594	-0.1696	-0.1220	-0.1828
23	-0.0162	-0.0196	0.0324	-0.0465	0.1661	-0.1695	-0.1034	0.1287
24	-0.0136	0.0921	-0.0552	-0.0092	-0.1583	0.1550	0.1610	-0.0516
25	0.1221	-0.1129	-0.0623	-0.0851	0.1879	-0.1285	-0.0321	-0.1684
26	-0.0704	0.2786	-0.1034	-0.2119	0.0842	-0.2199	0.1811	0.2574
27	-0.0320	-0.1001	0.2036	0.0500	-0.2384	0.3187	-0.0774	-0.0546
28	0.0328	-0.2375	0.2669	-0.2099	0.0115	-0.0512	-0.2625	-0.0892
29	-0.2479	-0.1680	0.2799	0.4327	-0.1357	-0.0452	-0.1519	-0.0988
30	0.2193	0.1069	-0.4765	0.1447	0.1587	0.0796	0.2128	-0.0945
31	-0.2150	0.1114	0.1788	0.0556	-0.1451	-0.0242	0.0424	0.1566
32	-0.1357	0.1782	0.2473	-0.3696	-0.0402	-0.1791	0.1268	0.1367
33	0.1328	-0.0938	-0.0746	-0.0641	-0.1359	0.2839	-0.2918	0.1335
34	0.0793	-0.0077	-0.2444	0.2260	0.0157	0.1165	0.1287	-0.1408
35	-0.0720	-0.0859	0.0754	0.2035	0.1558	-0.2121	0.0138	-0.1721
36	-0.1207	-0.0769	0.3556	-0.0085	-0.0430	-0.1805	-0.1155	0.0180
37	0.1918	-0.5016	0.1557	0.3540	0.2140	0.0537	-0.4127	-0.3285

TABLE 18--Continued

	COL. 9	COL. 10	COL. 11	COL. 12	COL. 13	COL. 14	COL. 15	COL. 16
1	0.2046	0.2942	0.2581	-0.3313	-0.1166	0.0244	0.0217	-0.0009
2	-0.0073	-0.0423	0.0055	0.1159	0.0323	0.1159	-0.2050	0.0676
3	-0.2560	-0.2891	-0.2956	0.2581	0.1553	-0.0262	0.3012	-0.0611
4	0.0175	-0.1208	-0.1208	0.1123	0.0722	-0.1808	-0.1791	0.0213
5	0.1309	0.1078	0.1384	-0.0511	-0.0576	-0.0425	0.1584	-0.1606
6	0.1907	0.2376	0.1621	-0.3418	-0.1681	0.0749	-0.1216	0.1554
7	-0.0890	-0.1133	-0.0486	0.2091	-0.0492	0.1026	-0.1384	0.1434
8	0.0802	0.0947	0.0964	-0.0852	0.1265	0.0747	-0.1944	-0.0830
9	1.0000	0.2249	0.2155	-0.2240	0.1474	-0.0516	-0.1475	0.0238
10	0.2249	1.0000	0.9832	-0.9560	-0.1857	0.2748	0.0825	0.1463
11	0.2155	0.9832	1.0000	-0.8863	-0.1692	0.2934	0.0806	0.1718
12	-0.2240	-0.9560	-0.8863	1.0000	0.1989	-0.2255	-0.0797	-0.0949
13	0.1474	-0.1857	-0.1692	0.1989	1.0000	-0.0135	-0.1014	0.1826
14	-0.0516	0.2748	0.2934	-0.2255	-0.0135	1.0000	0.1272	0.3709
15	-0.1475	0.0825	0.0806	-0.0797	-0.1014	0.1272	1.0000	-0.0568
16	0.0238	0.1463	0.1718	-0.0949	0.1826	0.3709	-0.0568	1.0000
17	-0.1896	0.1300	0.1173	-0.1411	-0.9269	-0.0825	0.0966	-0.2099
18	0.0457	-0.2336	-0.2218	0.2358	0.9429	-0.0747	-0.0549	0.1985
19	-0.0299	-0.3023	-0.3142	0.2617	-0.0094	-0.8602	-0.1207	-0.4139
20	0.0185	0.2932	0.3210	-0.2025	-0.0710	0.8222	0.0302	0.4575
21	0.1337	-0.0438	-0.0391	0.0483	0.0931	-0.1087	-0.9402	0.0165
22	-0.1545	0.1166	0.1206	-0.1019	-0.1049	0.1331	0.9207	-0.0783
23	-0.0440	-0.0728	-0.0918	0.0372	-0.2241	-0.3585	0.0476	-0.9817
24	0.0282	0.2201	0.2459	-0.1631	0.1366	0.3600	-0.0154	0.9820
25	0.0710	0.1636	0.1850	-0.1178	0.2020	0.1611	0.1456	0.0123
26	0.0197	0.1102	0.1812	0.0115	0.0110	0.1773	0.0064	0.0120
27	0.1360	-0.1160	-0.1490	0.0549	0.1247	-0.1442	0.0847	-0.1579
28	-0.3461	0.0843	0.0347	-0.1579	0.1019	0.0476	0.2831	0.0351
29	0.1315	-0.2269	-0.2329	0.2011	0.0337	-0.1887	-0.2544	-0.0320
30	0.1414	0.0191	0.0188	-0.0181	-0.2292	-0.0202	-0.2008	0.0910
31	0.1746	-0.0882	-0.0457	0.1501	0.1086	-0.0234	-0.0702	-0.1075
32	-0.1757	-0.2007	-0.2062	0.1776	0.0157	0.1940	0.2177	0.0780
33	0.0210	0.2963	0.2847	-0.2939	0.0987	0.0757	0.0012	0.0349
34	-0.0568	0.1493	0.1258	-0.1763	-0.1758	-0.1187	-0.1489	-0.0279
35	0.2214	-0.2366	-0.1949	0.2868	0.0751	-0.1473	-0.0679	-0.0845
36	-0.1515	-0.2333	-0.2538	0.1840	0.1588	0.0105	0.1444	-0.0572
37	0.0010	0.0967	0.0830	-0.1118	-0.0662	-0.2653	0.0758	-0.1357

TABLE 18--Continued

	COL. 17	COL. 18	COL. 19	COL. 20	COL. 21	COL. 22	COL. 23	COL. 24
1	-0.0164	-0.1933	-0.1715	-0.0198	-0.0338	-0.0032	-0.0162	-0.0136
2	0.0967	-0.0017	0.0124	0.2431	0.1942	-0.1966	-0.0196	0.0921
3	-0.0988	0.2546	0.0590	-0.1687	-0.2906	0.2895	0.0324	-0.0552
4	-0.0474	0.1264	0.1908	-0.0849	0.1520	-0.1571	-0.0465	-0.0092
5	-0.0029	-0.0892	0.0747	-0.0700	-0.1220	0.1594	0.1661	-0.1583
6	0.0813	-0.1982	-0.2650	0.0882	0.0477	-0.1696	-0.1695	0.1550
7	0.1161	-0.0458	0.0675	0.1842	0.1496	-0.1220	-0.1034	0.1610
8	0.0479	0.0815	-0.0162	0.1793	0.1765	-0.1828	0.1287	-0.0516
9	-0.1896	0.0457	-0.0299	0.0185	0.1337	-0.1545	-0.0440	0.0282
10	0.1300	-0.2336	-0.3023	0.2832	-0.0438	0.1166	-0.0728	0.2201
11	0.1173	-0.2218	-0.3142	0.3210	-0.0391	0.1206	-0.0918	0.2459
12	-0.1411	0.2358	0.2617	-0.2025	0.0483	-0.1019	0.0372	-0.1631
13	-0.9269	0.9429	-0.0094	-0.0710	0.0931	-0.1049	-0.2241	0.1366
14	-0.0825	-0.0747	-0.8602	0.8222	-0.1087	0.1331	-0.3585	0.3600
15	0.0966	-0.0549	-0.1207	0.0302	-0.9402	0.9207	0.0476	-0.0154
16	-0.2099	0.1885	-0.4139	0.4575	0.0155	-0.0783	-0.9817	0.9820
17	1.0000	-0.7985	0.1472	0.0752	-0.0666	0.1380	0.2725	-0.1418
18	-0.7985	1.0000	0.1398	-0.1103	0.0921	-0.0090	-0.2055	0.1702
19	0.1472	0.1398	1.0000	-0.7469	0.1917	-0.0224	0.4419	-0.3670
20	0.0752	-0.1103	-0.7469	1.0000	-0.0003	0.0759	-0.4350	0.4540
21	-0.0665	0.0921	0.1917	-0.0003	1.0000	-0.7467	-0.0014	-0.0077
22	0.1380	-0.0090	-0.0224	0.0759	-0.7467	1.0000	0.0788	-0.0201
23	0.2725	-0.2055	0.4419	-0.4350	-0.0014	0.0788	1.0000	-0.9388
24	-0.1418	0.1702	-0.3670	0.4540	-0.0077	-0.0201	-0.9388	1.0000
25	-0.2966	0.1632	-0.1515	0.0746	-0.0111	0.1723	-0.0119	-0.0026
26	0.0156	-0.0472	-0.0872	0.1664	-0.0059	0.0218	0.0025	0.0069
27	-0.1758	0.1227	0.0878	-0.2496	-0.0794	0.0804	0.1107	-0.1409
28	-0.0949	0.1221	-0.0675	-0.0814	-0.2480	0.2774	-0.0173	0.0370
29	0.0642	0.1689	0.2377	-0.1564	0.2509	-0.2200	0.0389	-0.0333
30	0.1725	-0.2653	-0.0265	0.1816	0.1631	-0.2296	-0.0932	0.0826
31	-0.0662	0.1221	0.0972	-0.0855	0.0723	-0.0408	0.0942	-0.1020
32	-0.0209	-0.0513	-0.1663	0.1256	-0.2766	0.1222	-0.1181	0.0785
33	-0.0134	0.1265	-0.2170	0.1788	0.0254	0.0690	-0.0144	0.0401
34	0.0813	-0.2262	0.1899	-0.1169	0.1938	-0.1212	0.0330	-0.0328
35	-0.0517	0.1498	0.1793	-0.1779	0.0555	-0.0641	0.1008	-0.0848
36	-0.1249	0.1063	-0.1135	-0.0252	-0.2321	0.0135	0.0189	-0.0756
37	0.0615	0.0306	0.2703	-0.3694	-0.0820	0.0955	0.1485	-0.1165

TABLE 18--Continued

	COL. 25	COL. 26	COL. 27	COL. 28	COL. 29	COL. 30	COL. 31	COL. 32
1	0.1221	-0.0704	-0.0320	0.0328	-0.2479	0.0193	-0.2150	-0.1357
2	-0.1129	0.2786	-0.1001	-0.2375	-0.1680	0.1069	0.1114	0.1782
3	-0.0623	-0.1034	0.2036	0.2669	0.2799	-0.4765	0.1788	0.2473
4	-0.0851	-0.2119	0.0500	-0.2095	0.4327	0.1447	0.0556	-0.3696
5	0.1879	0.0842	-0.2384	0.0115	-0.1357	0.1587	-0.1451	-0.0402
6	-0.1285	-0.2199	0.3187	-0.0512	-0.0452	0.0796	-0.0242	-0.1791
7	-0.0321	0.1811	-0.0774	-0.2625	-0.1519	0.2128	0.0424	0.1268
8	-0.1684	0.2574	-0.0546	-0.0892	-0.0988	-0.0945	0.1566	0.1867
9	0.0710	0.0197	0.1360	-0.3461	0.1315	0.1414	0.1746	-0.1757
10	0.1636	0.1102	-0.1160	0.0843	-0.2269	0.0191	-0.0882	-0.2007
11	0.1850	0.1812	-0.1490	0.0347	-0.2329	0.0188	-0.0457	-0.2062
12	-0.1178	0.0115	0.0549	-0.1575	0.2011	-0.0181	0.1501	0.1776
13	0.2020	0.0110	0.1247	0.1019	0.0337	-0.2292	0.1086	0.0157
14	0.1611	0.1773	-0.1442	0.0476	-0.1887	-0.0202	-0.0234	0.1940
15	0.1456	0.0064	0.0847	0.2831	-0.2544	-0.2008	-0.0702	0.2177
16	0.0123	0.0120	-0.1579	0.0351	-0.0320	0.0910	-0.1075	0.0780
17	-0.2966	0.0156	-0.1758	-0.0945	0.0642	0.1725	-0.0662	-0.0209
18	0.1632	-0.0472	0.1227	0.1221	0.1689	-0.2653	0.1221	-0.0513
19	-0.1515	-0.0372	0.0878	-0.0875	0.2377	-0.0265	0.0972	-0.1663
20	0.0746	0.1664	-0.2496	-0.0814	-0.1564	0.1816	-0.0855	0.1256
21	-0.0111	-0.0059	-0.0794	-0.2460	0.2509	0.1631	0.0723	-0.2766
22	0.1723	0.0218	0.0804	0.2774	-0.2200	-0.2296	-0.0408	0.1222
23	-0.0119	0.0025	0.1107	-0.0173	0.0389	-0.0932	0.0942	-0.1181
24	-0.0026	0.0069	-0.1409	0.0370	-0.0333	0.0826	-0.1020	0.0765
25	1.0000	0.1532	-0.0518	0.0484	-0.1652	-0.0787	0.0258	-0.1085
26	0.1532	1.0000	-0.2599	-0.3953	-0.1961	-0.3953	0.6742	0.1532
27	-0.0518	-0.2599	1.0000	-0.2055	-0.1020	-0.2055	0.3505	0.1155
28	0.0484	-0.3953	-0.2055	1.0000	-0.1550	-0.3125	-0.5863	0.0484
29	-0.1652	-0.1961	-0.1020	-0.1550	1.0000	-0.1550	0.2644	-0.1652
30	-0.0787	-0.3953	-0.2055	-0.3125	-0.1550	1.0000	-0.5863	-0.2059
31	0.0258	0.6742	0.3505	-0.5863	0.2644	-0.5863	1.0000	0.1342
32	-0.1085	0.1532	0.1155	0.0484	-0.1652	-0.2059	0.1342	1.0000
33	0.0848	-0.1231	-0.1920	0.2530	0.0805	-0.0195	-0.1992	-0.3111
34	0.2226	0.1118	-0.0697	-0.2298	-0.1754	0.2652	-0.0302	-0.3767
35	-0.2059	-0.1581	0.1397	-0.0500	0.2791	-0.0500	0.0853	-0.3330
36	-0.0188	0.0093	-0.1877	0.1395	0.2197	-0.1400	0.0004	0.5348
37	-0.1645	-0.3664	0.1192	0.0355	0.2829	0.1084	-0.1226	-0.4767

TABLE 18--Continued

	COL. 33	COL. 34	COL. 35	COL. 36	COL. 37
1	0.1328	0.0793	-0.0720	-0.1207	0.1918
2	-0.0938	-0.0072	-0.0859	-0.0769	-0.5016
3	-0.0745	-0.2444	0.0758	0.3556	0.1557
4	-0.0641	0.2260	0.2035	-0.0085	0.3540
5	-0.1359	0.0157	0.1558	-0.0430	0.2140
6	0.2839	0.1165	-0.2121	-0.1805	0.0537
7	-0.2918	0.1287	0.0138	-0.1155	-0.4127
8	0.1335	-0.1408	-0.1721	0.0180	-0.3285
9	0.0210	-0.0568	0.2214	-0.1515	0.0010
10	0.2963	0.1493	-0.2366	-0.2333	0.0967
11	0.2847	0.1258	-0.1949	-0.2538	0.0830
12	-0.2939	-0.1763	0.2868	0.1840	-0.1118
13	0.0987	-0.1758	0.0751	0.1588	-0.0662
14	0.0757	-0.1187	-0.1473	0.0105	-0.2653
15	0.0012	-0.1489	-0.0679	0.1444	0.0758
16	0.0349	-0.0279	-0.0845	-0.0572	-0.1357
17	-0.0134	0.0813	-0.0517	-0.1249	0.0615
18	0.1265	-0.2062	0.1498	0.1063	0.0306
19	-0.2170	0.1899	0.1793	-0.1135	0.2703
20	0.1788	-0.1169	-0.1779	-0.0253	-0.3694
21	0.0254	0.1938	0.0555	-0.2321	-0.0820
22	0.0690	-0.1212	-0.0641	0.0135	0.0955
23	-0.0144	0.0330	0.1008	0.0189	0.1485
24	0.0401	-0.0328	-0.0848	-0.0756	-0.1165
25	0.0848	0.2226	-0.2059	-0.0188	-0.1645
26	-0.1231	0.1118	-0.1581	0.0093	-0.3664
27	-0.1920	-0.0697	0.1397	-0.1877	0.1192
28	0.2530	-0.2298	-0.0500	0.1395	0.0355
29	0.0805	-0.1754	0.2791	0.2197	0.2829
30	-0.0195	0.2652	-0.0500	-0.1400	0.1084
31	-0.1992	-0.0302	0.0853	0.0004	-0.1226
32	-0.3111	-0.3767	-0.3330	0.5348	-0.4767
33	1.0000	-0.3303	-0.2919	-0.1538	0.0745
34	-0.3303	1.0000	-0.3536	-0.2138	0.1638
35	-0.2919	-0.3536	1.0000	-0.1771	0.2465
36	-0.1538	-0.2138	-0.1771	1.0000	-0.0547
37	0.0745	0.1638	0.2465	-0.0547	1.0000

TABLE 19

PERCENTAGES OF QUESTIONS ASKED IN THE FOUR CATEGORIES OF LEVEL I OF THE QUESTION CATEGORY SYSTEM, POST-TEST LESSON

Student Teacher	Closed	Open	Percentage Managerial	Rhetorical	Unclassifiable
			TREATMENT GROUP R_1		
0111	53.33	16.67	13.33	3.33	13.33
0512	42.86	32.14	17.86	3.57	3.57
0813	87.50	6.25	3.13	0.0	3.13
1411	75.00	0.0	25.00	0.0	0.0
2013	66.00	14.00	18.00	0.0	2.00
2112	30.00	55.00	15.00	0.0	0.0
2511	20.00	13.33	53.33	0.0	13.33
2911	60.00	5.71	20.00	2.86	11.43
3212	69.23	3.85	23.08	0.0	3.85
4011	65.00	10.00	25.00	0.0	0.0
4213	60.00	0.0	37.14	2.86	0.0
			TREATMENT GROUP R_2		
0222	68.75	0.0	18.75	12.50	0.0
0421	81.25	0.0	15.63	0.0	3.13
0622	53.06	6.12	16.33	10.20	14.29
1223	60.00	0.0	40.00	0.0	0.0
1821	81.82	0.0	18.18	0.0	0.0
2723	75.51	4.08	14.29	2.04	4.08
3021	67.80	0.0	13.56	8.47	10.17
3322	79.55	9.09	2.27	9.09	0.0
3921	33.33	50.00	5.56	0.0	11.11

TABLE 19--Continued

	Percentage				
Student Teacher	Closed	Open	Managerial	Rhetorical	Unclassifiable
TREATMENT GROUP R_3					
0931	29.41	17.65	23.53	5.88	23.53
1133	90.48	0.0	2.38	7.14	0.0
1333	66.67	4.17	20.83	4.17	4.17
1532	27.27	18.18	18.18	36.36	0.0
1731	37.50	31.25	18.75	6.25	6.25
2232	83.33	16.67	0.0	0.0	0.0
2631	61.29	3.23	25.81	3.23	6.45
2832	95.24	0.0	4.76	0.0	0.0
3131	48.65	21.62	13.51	10.81	5.41
3632	60.00	0.0	26.67	13.33	0.0
3833	82.93	7.32	0.0	7.32	2.44
4133	87.88	0.0	3.03	3.03	6.06
TREATMENT GROUP R_4					
0342	90.00	6.67	0.0	0.0	3.33
0741	52.17	0.0	26.09	8.70	13.04
1043	25.00	0.0	37.50	25.00	12.50
1641	79.59	2.04	12.24	6.12	0.0
1942	42.11	42.11	5.26	5.26	5.26
2343	77.78	0.0	11.11	5.56	5.56
2441	60.00	20.00	8.57	2.86	8.57
3442	59.26	0.0	29.63	7.41	3.70
3543	38.89	5.56	38.89	16.67	0.0
3741	66.67	4.17	25.00	4.17	0.0

TABLE 20

PERCENTAGES* OF QUESTIONS ASKED IN THE FOUR CATEGORIES OF LEVEL II OF THE QUESTION CATEGORY SYSTEM, POST-TEST LESSON

Student Teacher	Cognitive-Memory Thinking	Convergent Thinking	Divergent Thinking	Evaluative Thinking	Unclassifiable
		TREATMENT GROUP R_1			
0111	6.67	36.67	16.67	0.0	23.33
0512	14.29	17.86	25.00	7.14	14.29
0813	40.63	31.25	6.25	0.0	18.75
1411	43.75	25.00	0.0	0.0	6.25
2013	28.00	34.00	6.00	4.00	10.00
2112	20.00	0.0	25.00	30.00	10.00
2511	20.00	0.0	6.67	6.67	13.33
2911	34.29	17.14	2.86	2.86	20.00
3212	53.85	3.85	0.0	0.0	19.23
4011	27.50	32.50	10.00	0.0	5.00
4213	25.71	31.43	0.0	0.0	0.0
		TREATMENT GROUP R_2			
0222	31.25	31.25	0.0	0.0	6.25
0421	59.38	15.63	0.0	0.0	9.38
0622	10.20	36.73	6.12	0.0	20.41
1223	10.00	30.00	0.0	0.0	20.00
1821	27.27	36.36	0.0	0.0	18.18
2723	51.02	20.41	4.08	0.0	8.16
3021	13.56	52.54	0.0	0.0	11.86
3322	20.45	52.27	0.0	4.55	11.36
3921	0.0	33.33	5.56	33.33	22.22

TABLE 20--Continued

Student Teacher	Cognitive-Memory Thinking	Convergent Thinking	Divergent Thinking	Evaluative Thinking	Unclassifiable
		TREATMENT GROUP R_3			
0931	5.88	17.65	17.65	0.0	29.41
1133	50.00	40.48	0.0	0.0	0.0
1333	33.33	20.83	4.17	0.0	16.67
1532	18.18	9.09	18.18	0.0	0.0
1731	6.25	25.00	31.25	0.0	12.50
2232	41.67	41.67	8.33	8.33	0.0
2631	12.90	45.16	3.23	0.0	9.68
2832	90.48	4.76	0.0	0.0	0.0
3131	13.51	10.81	16.22	2.70	32.43
3632	6.67	53.33	0.0	0.0	0.0
3833	43.90	31.71	7.32	0.0	9.76
4133	42.42	42.42	0.0	0.0	9.09
		TREATMENT GROUP R_4			
0342	66.67	20.00	3.33	3.33	6.67
0741	26.09	13.04	0.0	0.0	26.09
1043	25.00	0.0	0.0	0.0	12.50
1641	73.47	4.08	2.04	0.0	2.04
1942	42.11	0.0	36.84	0.0	10.53
2343	16.67	61.11	0.0	0.0	5.56
2441	14.29	31.43	20.00	0.0	22.86
3442	22.22	33.33	0.0	0.0	7.41
3543	22.22	16.67	5.56	0.0	0.0
3741	45.83	16.67	4.17	0.0	4.17

*Percentages for Managerial and Rhetorical Questions have been subtracted from the total for each student teacher at this level

TABLE 21

PAUSE TIME MEANS (IN SECONDS), PERCENTAGE OF TEACHER TALK BY TREATMENT GROUP, POST-TEST LESSON

Student Teacher	Pause Time Mean	Teacher Talk
	TREATMENT GROUP R_1	
0111	2.29	41
0512	1.72	67
0813	1.94	76
1411	2.69	77
2013	2.84	54
2112	2.56	56
2511	2.52	62
2911	2.24	76
3212	2.95	52
4011	2.15	72
4213	2.77	80
	TREATMENT GROUP R_2	
0222	1.50	93
0421	1.71	80
0622	1.08	57
1223	2.18	99
1821	2.00	79
2723	1.88	91
3021	1.78	81
3322	2.22	63
3921	1.28	64

TABLE 21--Continued

Student Teacher	Pause Time Mean	Teacher Talk
TREATMENT GROUP R_3		
0931	1.00	76
1133	1.98	90
1333	1.88	99
1532	2.07	92
1731	2.27	73
2232	1.32	74
2631	1.68	66
2832	1.68	76
3131	2.10	58
3632	0.91	84
3833	2.05	88
4133	1.58	87
TREATMENT GROUP R_4		
0342	1.42	87
0741	2.33	90
1043	2.47	98
1641	1.03	74
1942	0.87	69
2343	2.17	95
2441	1.38	51
3442	1.00	80
3543	2.73	95
3741	1.81	90

TABLE 22

COMPARISON OF CORRELATION COEFFICIENTS FOR TREATMENT GROUP AND SUBSAMPLE FOR QUESTION TYPES OF LEVEL I, PAUSE TIME MEAN, AND PERCENTAGE OF TEACHER TALK DURING THE POST-TEST

Variable	R_1		R_2		R_3		R_4	
	Total	Subsample	Total	Subsample	Total	Subsample	Total	Subsample
	(N=11,6)		(N=9,3)		(N=12,4)		(N=10,4)	
Closed Questions	-0.136	-0.091	0.133	0.199	0.079	-0.219	-0.072	0.143
Open Questions	0.178	0.271	-0.094	-0.282	-0.007	0.169	-0.086	-0.222
Managerial Questions	0.247	0.088	-0.075	0.235	-0.244	-0.246	0.076	-0.064
Rhetorical Questions	-0.370	-0.373	-0.064	-0.128	0.226	0.507*	0.204	0.029
Pause Time	0.535*	0.632*	-0.154	-0.292	-0.214	-0.067	-0.177	-0.382
Teacher Talk	-0.477*	-0.533*	0.075	0.162	0.164	0.239	0.247	0.215

*Significant at the .10 level or greater

TABLE 23

SIGNIFICANT POSITIVE CORRELATIONS FOR THIRD AUDIOTAPE

Variable	Correlation Coefficient
CLOSED QUESTIONS	
Cognitive-Memory Questions	0.870
E-I continuum	0.645
Intraversion	0.560
Feeling	0.427
Pause Time Mean	0.504
OPEN QUESTIONS	
Divergent Thinking Questions	0.975
Extroversion	0.623
Intuition	0.418
R_3	0.490
MANAGERIAL QUESTIONS	
Evaluative Thinking Questions	0.570
Teacher Talk	0.494
RHETORICAL QUESTIONS	
R_4	0.435
PAUSE TIME	
Closed Questions	0.504
Cognitive-Memory Questions	0.431
ESSfactual	0.467
Student teaching: biology	0.478
R_1	0.576
TEACHER TALK	
Managerial Questions	0.494
Sensing	0.438
Thinking	0.426

TABLE 24

SIGNIFICANT NEGATIVE CORRELATIONS FOR THIRD AUDIOTAPE

Variable	Correlation Coefficient
CLOSED QUESTIONS	
Open Questions	-0.597
Managerial Questions	-0.607
Divergent Thinking Questions	-0.458
Evaluative Thinking Questions	-0.694
Extroversion	-0.604
OPEN QUESTIONS	
Cognitive-Memory Questions	-0.538
E-I continuum score	-0.622
Intraversion	-0.548
MANAGERIAL QUESTIONS	
Cognitive-Memory Questions	-0.503
R_3	-0.576
RHETORICAL QUESTIONS	
Student teaching: biology	-0.423
Pause Time Mean	-0.651
PAUSE TIME	
Rhetorical Questions	-0.651
R_4	-0.436
TEACHER TALK	
T-F continuum score	-0.420

TABLE 25

ONE-WAY ANALYSIS OF VARIANCE OF CLOSED QUESTIONS ASKED BY TREATMENT GROUPS DURING POST-TEST AS COMPARED WITH THIRD AUDIOTAPE

Source of Variation	Sum of Squares	Degrees of Freedom	Variance Estimate	F
		TREATMENT GROUP R_1		
Between	544.72	1	544.72	1.2092
Within	4504.77	10	450.48	
Total	5049.49	11		
		TREATMENT GROUP R_2		
Between	1157.59	1	1157.59	4.0526
Within	1142.57	4	285.64	
Total	2300.16	5		
		TREATMENT GROUP R_3		
Between	74.54	1	74.54	0.1157
Within	3865.80	6	644.30	
Total	3940.34	7		

TABLE 26

ONE-WAY ANALYSIS OF VARIANCE OF OPEN QUESTIONS ASKED BY TREATMENT GROUPS DURING POST-TEST AS COMPARED WITH THIRD AUDIOTAPE

Source of Variation	Sum of Squares	Degrees of Freedom	Variance Estimate	F
		TREATMENT GROUP R_1		
Between	114.26	1	114.26	0.4274
Within	2673.50	10	267.35	
Total	2787.76	11		
		TREATMENT GROUP R_2		
Between	6.53	1	6.53	0.2055
Within	127.14	4	31.78	
Total	133.67	5		
		TREATMENT GROUP R_3		
Between	169.28	1	169.28	0.4165
Within	2438.69	6	406.45	
Total	2607.97	7		
		TREATMENT GROUP R_4		
Between	0.15	1	0.15	0.0022
Within	404.84	6	67.47	
Total	404.99	7		

TABLE 27

ONE-WAY ANALYSIS OF VARIANCE OF MANAGERIAL QUESTIONS
ASKED BY TREATMENT GROUPS DURING POST-TEST
AS COMPARED WITH THIRD AUDIOTAPE

Source of Variation	Sum of Squares	Degrees of Freedom	Variance Estimate	F
		TREATMENT GROUP R_2		
Between	925.29	1	925.29	3.9757
Within	930.93	4	232.73	
Total	1856.22	5		
		TREATMENT GROUP R_3		
Between	45.65	1	45.65	0.2496
Within	1097.22	6	182.87	
Total	1142.87	7		

TABLE 28

ONE-WAY ANALYSIS OF VARIANCE OF RHETORICAL QUESTIONS ASKED BY TREATMENT GROUPS DURING POST-TEST AS COMPARED WITH THIRD AUDIOTAPE

Source of Variation	Sum of Squares	Degrees of Freedom	Variance Estimate	F
		TREATMENT GROUP R_1		
Between	66.41	1	66.41	3.2769
Within	202.66	10	20.27	
Total	269.07	11		
		TREATMENT GROUP R_2		
Between	47.26	1	47.26	1.3900
Within	136.01	4	34.00	
Total	183.27	5		
		TREATMENT GROUP R_3		
Between	60.99	1	60.99	0.4490
Within	815.17	6	135.86	
Total	876.16	7		

TABLE 29

ONE-WAY ANALYSIS OF VARIANCE OF PAUSE MEAN TIME BY TREATMENT GROUPS DURING POST-TEST AS COMPARED WITH THIRD AUDIOTAPE

Source of Variation	Sum of Squares	Degrees of Freedom	Variance Estimate	F
		TREATMENT GROUP R_1		
Between	0.04	1	0.04	0.0620
Within	6.40	10	0.64	
Total	6.44	11		
		TREATMENT GROUP R_2		
Between	0.17	1	0.17	0.7719
Within	0.88	4	0.22	
Total	1.05	5		
		TREATMENT GROUP R_3		
Between	0.37	1	0.37	1.5698
Within	1.41	6	0.24	
Total	1.78	7		
		TREATMENT GROUP R_4		
Between	1.03	1	1.03	2.6950
Within	2.29	6	0.38	
Total	3.32	7		

TABLE 30

ONE-WAY ANALYSIS OF VARIANCE OF PERCENTAGE OF TEACHER TALK BY TREATMENT GROUPS DURING POST-TEST AS COMPARED WITH THIRD AUDIOTAPE

Source of Variation	Sum of Squares	Degrees of Freedom	Variance Estimate	F
		TREATMENT GROUP R_1		
Between	126.75	1	126.75	0.4579
Within	2768.16	10	276.82	
Total	2894.91	11		
		TREATMENT GROUP R_2		
Between	54.00	1	54.00	0.1319
Within	1637.33	4	409.33	
Total	1691.33	5		
		TREATMENT GROUP R_3		
Between	648.00	1	648.00	1.1546
Within	3367.50	6	561.25	
Total	4015.50	7		
		TREATMENT GROUP R_4		
Between	578.00	1	578.00	0.6514
Within	5324.00	6	887.33	
Total	5902.00	7		

TABLE 31

COMPARISON OF QUESTION PRECENTAGES, LEVEL I: POST-TEST (MICROTEACHING LESSON) AND THIRD LESSON AUDIOTAPED DURING STUDENT TEACHING QUARTER

Student Teacher	Closed MTP/ATIII	Open MTP/ATIII	Managerial MTP/ATIII	Rhetorical MTP/ATIII	Unclassifiable MTP/ATIII
0111	53.33/18.52	16.67/29.63	13.33/40.74	3.33/ 7.41	13.33/ 3.70
2013	66.00/ 8.33	14.00/12.50	18.00/58.33	00.00/16.67	2.00/ 4.17
2112	30.00/41.67	55.00/12.50	15.00/45.83	00.00/00.00	00.00/00.00
2911	60.00/48.48	5.71/00.00	20.00/45.45	2.86/ 6.06	11.43/00.00
3212	69.23/80.00	3.85/00.00	23.08/20.00	00.00/00.00	3.85/00.00
4213	60.00/60.71	00.00/ 3.57	37.14/28.57	2.86/ 7.14	00.00/00.00
0622	53.06/52.94	6.12/00.00	16.33/35.29	10.20/11.76	14.29/00.00
1223	60.00/16.66	00.00/12.38	40.00/68.57	00.00/ 2.38	00.00/00.00
1821	81.82/41.94	00.00/00.00	18.18/45.16	00.00/12.90	00.00/00.00
1532	27.27/43.75	18.18/37.50	18.18/ 6.25	36.36/12.50	00.00/00.00
1731	37.50/68.57	31.25/ 5.71	18.75/ 8.57	6.25/11.43	6.25/ 5.71
2631	61.29/10.71	3.23/53.57	25.81/28.57	3.23/ 7.14	6.45/00.00
3833	82.93/61.54	7.32/00.00	00.00/38.46	7.32/00.00	2.44/00.00
0741	52.17/47.37	00.00/ 3.51	26.09/33.33	8.70/12.28	13.04/ 3.51
2343	77.78/58.33	00.00/ 2.08	11.11/27.08	5.56/12.50	5.56/00.00
2441	60.00/23.33	20.00/13.33	8.57/46.67	2.86/13.33	8.57/ 3.33
3442	59.26/37.50	00.00/00.00	29.63/50.00	7.41/12.50	3.70/00.00

TABLE 32

COMPARISON OF MEAN PAUSE TIMES: POST-TEST (MICROTEACHING LESSON) AND THIRD LESSON AUDIOTAPED DURING STUDENT TEACHING FOR TREATMENT GROUP SUBSAMPLES

Student Teacher	Mean Pause Time (in seconds) Post-test	Third Lesson
TREATMENT GROUP R_1		
0111	2.29	1.97
2013	2.84	1.50
2112	2.56	3.11
2911	2.24	1.45
3212	2.95	4.26
4213	2.77	2.16
TREATMENT GROUP R_2		
0622	1.08	1.77
1223	2.18	1.27
1821	2.00	1.20
TREATMENT GROUP R_3		
1532	2.07	1.47
1731	2.27	1.72
2631	1.68	0.80
3833	2.05	2.35
TREATMENT GROUP R_4		
0741	2.33	1.25
2343	2.17	1.47
2441	1.38	1.20
3442	1.00	1.22

TABLE 33

COMPARISON OF TEACHER TALK: POST-TEST (MICROTEACHING LESSON) AND THIRD LESSON AUDIOTAPED DURING STUDENT TEACHING (TREATMENT GROUP SUBSAMPLES)

Student Teacher	Percentage of Teacher Talk Post-test	 Third Lesson
TREATMENT GROUP R_1		
0111	41	28
2013	54	56
2112	56	39
2911	76	51
3212	52	72
4213	80	74
TREATMENT GROUP R_2		
0622	57	51
1223	99	89
1821	79	77
TREATMENT GROUP R_3		
1532	92	54
1731	73	83
2631	66	21
3833	88	89
TREATMENT GROUP R_4		
0741	90	72
2343	95	81
2441	51	72
3443	80	88

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HANDBOOK OF EFFECTIVE QUESTIONING TECHNIQUES

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September 1970

UNITED STATES DEPARTMENT OF
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PREFACE

This publication is Part Two of a two part final report of a study designed to assess the effectiveness of an instructional procedure aimed at developing skill in questioning. It consists of a handbook of effective questioning techniques used by the participants in the instructional procedure.

Part One consists of the report of the study, its methodology, data gathered and procedures used to analyze these data, as well as conclusions and recommendations for research and for educational practice.

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CHAPTER ONE
THE ROLE OF THE QUESTION IN THE CLASSROOM

Introduction

The purpose of this handbook is to provide some general information about questions and questioning techniques that might be used to stimulate good class discussions and to promote critical thinking on the part of students. ("Critical thinking" is here defined to refer to analyzing information to determine if it is based objective evidence or subjective judgments, to identify the source of statements, to learn to suspend judgment until as much information as possible can be obtained relative to a specific problem or question, etc.) The information contained in this handbook is meant to describe what may be done to stimulate thinking and encourage good class discussions rather than to prescribe what must be done.

Science teachers need to structure the classroom situation so that their students develop the ability to think for themselves and to think critically. Such structuring of the learning environment can be done, at least in part, through the effective use of questions. There are many different ways in which questions can be classified. For purposes of illustration here, we will speak of "open questions" and "closed questions."

"Open questions" are those for which there is a wide range of acceptable answers. Such questions do not limit what the students think or say when they attempt to answer. "Closed questions" are those for which only one right, or acceptable, answer is possible. A question such as "Who is given credit for explaining the circulation of the blood?" is considered a "closed question" as opposed to "What do you think our concept of 'life' would be like if all we could see of an individual were his hands, rather than seeing his whole body?"

Many, if not most, science teachers need to decrease the extent to which they dominate the talk, and the thinking, of students in their classes. Many ask a predominance of "closed questions." "Closed questions" tend to stress highly convergent minds. Students look for simple "right" answers and assume that "right" answers depend on authority rather than on rational judgment (Taba, p.80).

Teachers need to ask better questions. "Better questions" can be interpreted to mean questions that stimulate thinking that goes beyond the level of factual recall of information. Hopefully, if teachers can improve their questioning techniques and the quality of the questions they ask, they will not need to ask so many questions. If the questions teachers ask stimulate students to think and to analyze as well as react, questioning may come to be a student-initiated, rather than a teacher-dominated, activity.

The teacher's techniques of questioning should be such that these can serve as models for pupils as the pupils develop and improve their own questioning skills. Such model-building does not result from reading and thinking only, it requires conscious effort on the part of the teacher to develop good questions. It also requires practice in questioning. Reading this handbook and agreeing with its major premises is only one part of the development of questioning skill. The most important part is translating these ideas into actions or teaching strategies and using these in the classroom.

The role of the question in the classroom

The question is a commonly used teaching device. One of the traditional uses of questions has been to determine whether or not students have done their homework (Risk, p.258). Questions can, however, serve purposes other than checking on pupil preparation. Burton (p. 438) lists 11 purposes questions can serve, such as:

(1) stimulating reflective thought by requiring analysis, comparison, definition, interpretation, or the use of judgment;
(2) developing appreciations and attitudes;
(3) developing the power and habit of evaluation;
(4) determining the informational background, interests, and maturity of individuals or class groups; and
(5) creating interest, arousing purpose, or developing a mind-set.

Characteristics of good questions

According to Groisser (pp. 21-37), good questions possess the following characteristics:

(1) They are purposeful. They serve to channel the discussion along the path suggested by the teacher and/or the content and help to achieve the lesson objective or objectives.
(2) They are clear and easily understood. They leave no doubt in the student's mind as to what the teacher means.
(3) They are brief. Shorter questions are more easily understood than are long, involved ones.
(4) They are worded in such a way that they do not repeat the phraseology of the textbook.
(5) They are thought provoking.

(6) They are limited in scope. They ask for thinking and information but do not attempt to cover the entire lesson in one or two questions.
(7) They are adapted to the level of membership of the class. Questions should be difficult enough to stimulate thought but not so difficult that they are unanswerable.
(8) They are logically placed in the development of the lesson.

It is somewhat unrealistic to expect that one question will possess all eight of the characteristics listed, but this list can serve as a guideline when formulating questions.

A shorter list that serves the same purpose (providing a guideline) is as follows:

(1) Questions should be adapted to the purposes of the objectives of the discussion.
(2) The wording of questions should be clear, and the questions should be relatively brief and adapted to the nature of the problem under considerations.
(3) Questions should be adapted to the ability and experience of the group (Risk, p.260).

CHAPTER TWO
THE CLASSIFICATION OF QUESTIONS

Classification of questions

As stated earlier, questions may be classified in a variety of ways. Sometimes the division is that of fact questions, requiring low-level cognitive ability to answer, and thought questions, requiring the use of some of the higher-level cognitive processes such as inferring, judging, generalizing, hypothesizing, etc.

A different division is that of instructional questions, further subclassified on the basis of the teacher's purpose (see Appendix C for more discussion of this point), and managerial questions which serve the teacher in promoting the usual class routine. Managerial questions consist of solicitations such as "How many need more time to finish writing up lab reports" or "Who needs to work in the library this period?" or "Does everybody have at least two clean microscope slides?"

Another type of question teachers use is that termed rhetorical questions. These questions are used to reinforce points or for emphasis. The teacher really does not expect to receive an answer to a rhetorical question.

Questions may also be classified according to the type of thinking they are designed to promote on the part of the listener. One system in use is that found in the book, Classroom Questions: What Kinds, by Sanders. Sanders based his sytem on the levels of the cognitive domain described in Bloom's Taxonomy of Educational Objectives. The system used in this handbook differs from those of Bloom and Sanders, however, and is explained in the following paragraphs.

Question Category System for Science

The Question Category System for Science (QCSS) consists of three levels of classification. Questions are initially divided into closed questions, those for which there is a limited number of acceptable responses or "right" answers, and open questions, those for which there is a wide range of acceptable responses and not just one or two "right" answers.

The second level of classification divides the questions into four types of thinking: cognitive-memory, convergent thinking, divergent thinking, and evaluative thinking.

(1) COGNITIVE-MEMORY questions are defined as those which require the simple reproduction of facts, formulas, and other items of remembered content through the use of such processes as recognition, rote memory, or selective recall. These are considered to belong to the larger category of "closed questions."

Examples of cognitive-memory questions would be such as:

> What is the chemical formula for water?
> What is the boiling point of water, at normal atmospheric pressure, on the centrigrade scale?
> What are the names of the three classes of rocks?
> Who is credited with formulating the germ theory of disease?

Cognitive-memory memory questions frequently begin with "Who," "What," "Where," and, sometimes, "How" and "Why." These words are not always signs of this level of questioning. Solicitations such as "Name two examples of minerals" or "Give me the formula for glucose" also fit into this category.

When a teacher operates on the level of cognitive-memory thinking, he usually asks students to repeat something they have already said or heard, to recall some fact or idea, or to classify, with the basis for the classification being provided for the students. Other thinking operations are also possible in this category and are listed on a chart contained in this chapter.

(2) CONVERGENT THINKING questions are also considered to belong to the larger category of "closed questions." These questions may involve the analysis and integration of given or remembered data. These questions are designed to stimulate such mental activities as translation (of information in a slightly different context), association, explanation, and drawing conclusions.

Some examples of convergent thinking questions might be:

> Why will water boil at a lower temperature at a high altitude than it will at sea level?
> When you change the microscope magnification from low to high power, what frequently appears to happen to the object you are viewing? Why does this happen?
> From the data we now have about the planet Venus, what characteristics would "life" have to possess to survive there?
> When you find an area in which fossilized coral predominates in the rock, what can you infer about past geologic conditions when the rock containing the coral was formed?

Again, as with cognitive-memory questions, convergent thinking questions do not possess any "never-fail" identifying marks. A question which a teacher thinks is designed to produce convergent thinking may only be a cognitive-memory question for a student who has read widely, studied more than the assigned material, or who has encountered the question or one similar to it before.

Teachers use convergent thinking questions when they use questions designed to get students to associate facts or see relationships, to discriminate, reformulate, illustrate, explain something using previously acquired data, make a prediction within the limitations imposed by the conditions or evidence, or make critical judgments using arbitrarily imposed standards or criteria.

These two types of "closed questions" (cognitive-memory, convergent thinking) are frequently used when the class is involved in gaining or solidifying understanding of material or in reviewing.

"Open questions" (divergent thinking, evaluative thinking) may be used to stimulate interest, to provide motivation for further study, or to develop insights, appreciations or attitudes. "Open questions" may be used to introduce a new idea or topic or may come into use when the teacher thinks the class has acquired enough knowledge and understanding of the topic to go beyond the prescribed information and to use it to do other types of thinking, classified as divergent and evaluative.

(3) DIVERGENT THINKING questions are those in which the individuals questioned are free to generate their own data within a "data-poor" situation. The situation may be "data-poor" in that the teacher, the materials, or the assignment has not provided enough information to restrict thinking to certain pathways or to limit the types of answers which may be given. Divergent thinking questions may stimulate such

thinking operations as elaborating, divergent association, implication, or synthesis. When a teacher asks a divergent thinking question, he is not certain of the answer it may produce.

Such questions as the following may be place in the divergent thinking category:

> If the average temperature of the New England states were to be 20 degrees higher than it now is, what changes would this possibly bring about in the ecology of this area?
> What inferences can you make on the basis of the data you collected?
> What do you suppose might happen if we ran out of coal and oil?

Divergent thinking questions are designed to cause students to invent, to synthesize, to elaborate, to point out implications, or to make open predictions for which the data is insufficient to limit the response expected.

(4) EVALUATIVE THINKING questions deal with matters of value rather than matters of fact. They contain the implication that the individual responding may be called upon to justify his response. The standards or criteria involved in making the judgment may be explicit--set down by the teacher, by scientific evidence, by concensus, etc. or they may be implicit--internal criteria by which the student operates in his thinking. (Questions for which the teacher has previously set criteria for judgment and for which no justification is needed because all persons involved assume that these criteria are being used when the student answers are considered as belonging to the convergent thinking category.)

Examples of evaluative thinking questions might be:

> What procedure can you design to use in testing this hypothesis?
>
> Should we set up a policy whereby an individual's organs are automatically made available for transplant operations when the person dies?
>
> Some people say that we should be spending less money, time, and scientific effort in getting to the Moon and should be channeling this money and effort toward solving such problems as hunger and poverty on Earth. How do you feel about this matter?

Students may be involved in evaluative thinking when the question asked causes them to evaluate methods and procedures in the formulation of an experimental design, to judge matters of value, to criticize, or to give an opinion.

These four types of questions: cognitive-memory, convergent thinking, divergent thinking, and evaluative thinking all serve different purposes. Cognitive-memory and convergent thinking questions are considered as "closed questions" in that the teacher usually can determine the answers they will produce. Divergent thinking and evaluative thinking questions are considered to be "open questions" because the teacher usually cannot be certain what the student who is responding is going to say.

Teachers should learn to ask both "open questions" and "closed questions." Too often teachers are so preoccupied with helping their students gain a background of subject matter in their area that they never get beyond the levels of cognitive-memory and convergent thinking. However, the knowledge base or the criteria for evaluation must be present before a teacher can successfully use "open questions" as a part of the lesson discussion. When to use "open questions" becomes a matter that each teacher must determine for himself on the basis of the background he knows, or assumes, his students to possess.

The Question Category System for Science used in this handbook and described in the preceding pages is shown in chart form on the following page. In addition to "open questions" and "closed questions" with their subdivisions (cognitive-memory, convergent thinking, divergent thinking, evaluative thinking), the general categories of "managerial questions" and "rhetorical questions" are used. Personal observation in the classrooms of experienced teachers has produced data on questioning practices which emphasize the use of these two general categories as well as those of "open questions" and "closed questions."

The third level of the Question Category System for Science, that of the type of thinking operation the question calls for, is detailed in the chart. Further thinking operations could be added in each category if, or as, they are identified and found to be distinct from those already listed.

There is no guarantee that the thinking operation which the question is designed to stimulate will produce that particular response in any or all of the students hearing the question. The questions are classified on the basis of their intent as perceived by the listener and not on the basis of the response which the student makes.

The chart is intended to serve as a reference to be used in learning the category system. It may be used in various ways, depending upon the individual's preference. It can serve as a guide when the teacher is preplanning questions. Or, the teacher can preplan the

QUESTION CATEGORY SYSTEM

Level I	Level II	Level III
I. CLOSED QUESTIONS (limited number of acceptable responses)	A. COGNITIVE MEMORY*	1. RECALL: includes repeat, duplicate, memorized definitions 2. IDENTIFY or NAME or OBSERVE
	B. CONVERGENT THINKING*	1. ASSOCIATE and/or DISCRIMINATE; CLASSIFY 2. REFORMULATE 3. APPLY: previously acquired information to solution of new and/or different problem 4. SYNTHESIZE 5. CLOSED PREDICTION: limitations imposed by conditions or evidence 6. MAKE "CRITICAL" JUDGMENT: using standards commonly known by class
II. OPEN QUESTIONS (greater number of acceptable responses)	C. DIVERGENT THINKING*	1. GIVE OPINION 2. OPEN PREDICTION: data insufficient to limit response 3. INFER or IMPLY
	D. EVALUATIVE THINKING*	1. JUSTIFY: behavior, plan of action, position taken 2. DESIGN: new method(s), formulate hypotheses, conclusion(s) 3. JUDGE A: matters of value, linked with affective behaviors 4. JUDGE B: linked with cognitive behaviors
III. MANAGERIAL	Teacher uses to facilitate classroom operations, discussion	
IV. RHETORICAL	Teacher uses to reinforce a point; does not expect (or want) a response	

*1. Cognitive-memory: evidence understood to be directly available (textbook, previous lesson or discussion, film, filmstrip, chart, experiment, field trip, etc.)

2. Convergent thinking: evidence directly available but not in the form called for by question

3. Divergent thinking: evidence for response not directly available

4. Evaluative thinking: evidence may or may not be directly available; criteria for responding available, directly or indirectly. Implication that student may be called upon to provide a defense for his response.

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questions and then analyze them, using the QCS, to determine the question types and perhaps modify the questions if this analysis shows that there are too many questions of one type and too few of another to fit the lesson objectives. No hard and fast rules for the most efficient use of the Question Category System can be developed which would apply to any and all circumstances.

The Question Category System and the handbook of which it is a part are components of an instructional sequence designed to provide prospective secondary school science teachers with some help and guidance in recognizing the types of questions they ask. In addition, the instructional sequence has been planned to provide experience in formulating questions as a part of a lesson, both when preplanning and when reacting to the immediate teaching-learning situation in the classroom. Hopefully, the information in this handbook and the experiences in the instructional sequence will provide opportunities for structuring and guiding class discussion just as working with laboratory equipment provides some degree of familiarity with the equipment before using it in a classroom teaching situation.

Teachers learn, through experience, the kinds of questions to use in different situations and the methods of handling student answers or of shaping student behavior. Some advance preparation can be done so that these skills do not have to be developed by trial and error during student teaching or during the first few years on the job.

CHAPTER THREE
QUESTIONING STRATEGIES

Class discussion is a teaching tool that may be put to use in science as well as in other subjects. Discussion is used extensively to develop cognitive skills, attitudes, feelings and sensitivities, and to get the greatest possible use from the content being studied (Taba, p. 75). When conducting a discussion, the teacher must make on-the-spot decisions, diagnosis, and formulation of questions as well as maintain control of the class. Many student teachers are reluctant to take on the complexities of conducting a good discussion (there is probably no such thing as a "perfect" discussion). Often those who do attempt to conduct a discussion have it under such rigid control or plan so much content or include so many ideas that it ends up being a recitation session or a teacher lecture. The teacher does have to guide the discussion. However, he should structure it in such a fashion that the students listen to and respond to each other and not just to the teacher.

One main questioning strategy will be emphasized as a part of this instructional sequence. It may be divided into two parts:

(1) using questioning techniques to increase pupil verbal participations while decreasing the amount of teacher talk, and

(2) asking "open questions" as well as "closed questions."

Each of these parts will be discussed at some length in this chapter. Although the two parts have been separated for purposes of discussion, they should be considered together, and practiced together, as one strategy.

Part I. Using questioning techniques to decrease teacher talk

A frequent classroom questioning pattern is that of question-answer, question-answer, question-answer. This results from the teacher interacting with one student at a time. It also usually results in the teacher's domination of the discussion. Another pattern is that of teacher question or solicitation (a demand for information in the form of an imperative sentence rather than phrased as a question), pupil response, teacher reaction or reinforcement. Here, again, the teacher dominates the verbal interaction.

There are several possible routes leading away from this situation of teachers talking more than students. One can lead off from the use of pausing to stimulate pupil behavior which results in thinking (on the part of the pupils) and longer pupil responses. If the purpose of most questions teachers ask is to motivate students to think, then the teachers should pace the questions accordingly.

It has been suggested that, after asking a question, the teacher should pause five seconds before calling on a pupil or accepting a response in order to allow time for thinking (Minicourse One, p.22). Although the length of time is arbitrary, time should be allowed for students to think before they are required to answer.

If the questions are being used for purposes of reviewing some familiar material, the pace can be more rapid than if the students are encountering new material or if they are expected to analyze, synthesize, or evaluate before they respond.

The developers of the Minicourse cited on the previous page suggest that when "pausing behavior" is first used, the teacher may have to include some verbal cue to the students, such as "Take time to think carefully before you answer" or "Please give me a complete answer if I call on you." Such verbal prompting may eventually become unnecessary if the students become accustomed to the teacher's pausing behavior and recognize it as a signal for time to think before answering.

The teacher may use nonverbal cues to signal the pause for thinking by looking away from the class and glancing out the window, at his notes, or just staring off into space. Students tend to equate a stare from the teacher with a request for an answer. And, teachers need to learn to feel comfortable with pauses or lulls in the verbal activity in their classrooms. Sometimes they operate in a fashion that tends to imply that if there is no talking going on, there also is no thinking taking place.

The teacher should also reinforce the importance of taking time to think reflectively before answering by verbally or nonverbally rewarding complete, acceptable student responses and by indicating why unacceptable student responses are unacceptable (Minicourse One, pp.22-25).

If students are not allowed, encouraged or required to think before answering, they often give fragmentary answers or answers which magnify minor points while neglecting major ones. They may provide inadequate, unorganized answers or may include only one or two of several points. Their answers may be of the rambling variety, triggered perhaps by the hope that if they keep talking, they may eventually happen on the correct response. The teacher's method of questioning and the type of answer accepted will shape the students' habits of thinking and responding (Burton, p.447). Because one of the emphases in this strategy is to decrease the amount of teacher talk, the more nonverbal behavior a teacher can use, the better.

Teachers may increase pupil participation by accepting responses and then asking students to provide more information and/or more explanation. The teacher may, in some situations, request clarification or use other teaching techniques such as those which the Stanford Teacher Education Program publications call "probing" (see Appendix A).

If the teacher is encouraging pupils to give relatively detailed responses rather than accepting one word answers or short phrases, he needs to analyze his questions to determine if he is asking types of questions that require longer answers. Leading questions such as "So we can say that the nucleus is an essential part of most cells, isn't that correct?" or fill-in-the-blank type of questions such as "The green coloring matter in plant cells is -----?" are not likely to result in lengthy pupil answers.

Questions should be stated clearly so that the area within which the student is expected to operate in developing his answer is delimited. Asking such a question as "What about the cell membrane?" provides no clues as to possible avenues of thought to be followed (and may provoke a student to respond, or think of responding, "Yeah, what about it?"). Questions that can be answered with a "yes-no" answer are to be avoided if the teacher really wants students to think rather than guess. These questions can sometimes be salvaged and can call for a longer response by tacking a "Why?" on the end of the question. A better procedure would be to reword the question so that the student realizes he is expected to give reasons or justification as a part of his answer.

A teacher can begin encouraging pupils to produce longer responses by asking questions which have two or more parts to the answer, such as "What are at least three differences between plants and animals?" However, the teacher should avoid making these questions so complicated and detailed that they only serve to confuse the student when he attempts to identify what type of thinking operation the question requires him to perform.

Questions which have more than one part to the answer should not be confused with questions which are composed of several lumped together and treated as one question. For example, "Do you think it would be better if we were to test this hypothesis by manipulating the variables one at a time or can we alternate the variables we manipulate and still get accurate results or do you have some different procedure in mind?" is not one question but three and cannot be answered adequately without treating each question separately. Students confronted by such a situation have the additional problem of deciding which question to consider first as well as trying to decide on an answer. They may not even stay with the teacher to the end of such a question!

In order to increase the amount of student verbal interaction, questions may be asked that encourage more than one pupil to respond to them. This would serve to establish a pattern in which the pupils were talking more frequently than the teacher. One type of question that could be used to set up this pattern would be a question which has a number of alternatives, such as "There are many factors that determine weather conditions. Let's see how many we can identify. Tom, can you tell me one?" or "In the film we just saw, several different astronomical instruments were used. How many can we recall, one at a time (or one per person)?"

Another type of question which could establish this multiple-pupil response pattern would be one where large differences of opinion exist. In such a situation, no one pupil would have a definitive answer which would end the response sequence. Questions such as "In organ transplants, how should the decision that the donor is really dead be reached?" or "Do you think that UFO's really exist?" could serve as examples of this type. Another teaching situation in which more than one pupil would be stimulated to respond would be one in which the class was asked to analyze and interpret data, to formulate conclusions, or to set up hypotheses and design experiments to test these hypotheses.

Frequently teachers ask a question which allows more than one student to respond and then do not allow time for more than one response. Many have the tendency to charge ahead if the first answer fits their lesson plan and do not allow time for other contributions on the same point. Pacing is important but enough flexibility should be built into the lesson plans to allow for student reaction to and evaluation of other student responses.

Pupil-pupil interaction can be encouraged by bringing other students into the discussion by getting them to respond to the first student's answer. Such questions as "Does everyone agree with that?" or "Can you add anything to Tom's answer, Jim?" or "Would anyone like to modify or change any part of that answer?" may be used. The teacher may have to direct such questions to specific individuals in the beginning rather than using the impersonal pronouns "anyone, everyone, anybody" etc. Such questions should be used with both adequate and inadequate answers so that the students do not come to associate such a question arising only after an answer the teacher does not consider acceptable. Establishing the habit of student evaluation of answers should lead toward a class discussion that involves more of the class than does a "discussion" that is a series of teacher-student dialogues. However, you, as the teacher, have to remain alert to how well the student evaluations and responses relate to each other in order to avoid having the more verbal students monopolizing the discussion or having students disparaging each other's comments.

While establishing such pupil-pupil interaction patterns, the teacher may have to interject comments and transitional remarks until the patterns begin to be established. If he is alert and his strategy is successful, he can ease himself out of the verbal interaction.

Frequently it requires conscious, disciplined effort on the part of the teacher to keep silent and let his pupils do most of the talking.

One practice that should be avoided is that of repeating a question before calling on a second student to respond to it. Teachers tend to repeat or rephrase the question each time they involve another student in the discussion. This does not reduce the amount of teacher talk. It can be avoided by simply referring to the next student by name, pointing at him, or simply nodding in his direction.

Another practice to avoid is that of repeating the student's answer. Not only does this waste class time and increase the amount of teacher talk, it can lead to the tendency on the part of some students to listen only to what the teacher says because they come to realize that they will hear what their classmates have said when the teacher repeats the response. If the teacher wishes his students to listen to what their classmates have to say, he must establish a situation in which students have to listen to each other as well as to the teacher. If the teacher feels he must repeat the student's answer for his purposes of heading toward the lesson objectives, he should convert the answer into a question and direct it to another student or to the whole class. For instance, "John says he thinks the temperature will always decrease. Can anyone think of possible exceptions to this generalization?" or "Tell me what you think Sue meant when she said her results might have been due to sampling error."

In summary, the teacher's roles in class discussions will vary but the teacher needs to make a conscious effort to serve as guide and moderator rather than to set himself up as a source of wisdom. He should refrain from dominating the verbal interaction. He should guide, prod, clarify, and reflect, and refrain from lecturing, explaining, asserting, or telling. If he wants his pupils to associate science with the processing and critical evaluation of data, he must provide opportunities for them to do more than just passively acquire information and accept authority. Moreover, he should allow students time to think before they respond to his questions.

Figure 1, on the following page, provides an overview of some possible patterns of classroom interaction which have been discussed in the preceding pages.

Part II. Asking "open questions" as well as "closed questions"

"Closed questions" are defined in this handbook as those questions for which the response is predictable because the number of acceptable responses is limited. "Open questions" are those for which the specific response or form of the response is not predictable because there is a wide range of acceptable responses. Each of these divisions contains two smaller subdivisions. "Closed questions" are further divided into cognitive-memory and convergent thinking questions. "Open questions" contain the divisions of divergent thinking and evaluative thinking questions. These divisions and subdivisions were discussed in Chapter Two of the handbook and were summarized in the chart on page 12.

"Open questions" and "closed questions" serve different purposes in teaching. An over-emphasis on "closed questions" would appear to be

Patterns to be avoided

I. Teacher asks question
↓
Student responds
↓
Teacher {accepts / rejects / reinforces} student response
↓
Teacher asks question

II. Teacher asks question
↓
Student responds
↓
Teacher repeats question, calls on second student to respond

III. Teacher asks question
↓
Student responds
↓
Teacher repeats student's answer

NET RESULT: Teacher talks as much as students do--or more. Teacher probably talks more than students do because teacher talk is usually more detailed and involved than are student responses.

Patterns to be encouraged

I. Teacher asks question
↓
One student responds
↓
Second student responds to same question
↓
Additional students respond

II. Teacher asks question
↓
Student responds
↓
Second student comments on response
↓
Additional students enter discussion

III. Teacher asks question
↓
Student responds with question
↓
Teacher reflects question to student or to class
↓
Other students respond to student's question

IV. Teacher asks question
↓
Student responds
↓
Teacher requests additional responses

OR

Teacher asks for student evaluation of response

NET RESULT: More student participation and less teacher domination of the verbal interaction during class discussion.

Fig. 1: SOME POSSIBLE PATTERNS OF CLASSROOM VERBAL INTERACTION

contrary to all of the stated objectives of science teaching that relate to developing critical thinking individuals concerned with the processes of science as well as with scientific knowledge. Yet both experienced and beginning teachers who have been observed in action in their classrooms seem to be operating primarily at the cognitive-memory and convergent thinking levels in their questioning strategies. This situation may result from the particular lesson being taught. However, it may also be due in part to the fact that teachers spend little time in analyzing their questioning techniques.

When a teacher attempts to analyze his questioning techniques and the types of questions he asks, he is concerned not only with "What kinds of questions shall I ask to achieve my objectives for this lesson?" but also with "How many questions do I need to ask to accomplish my purposes?" Beginning teachers sometimes tend to think that a general rule of thumb to follow is "the more questions, the better." That is not necessarily true. A few carefully thought-out questions appropriately placed in the development of the lesson may do more to encourage student thinking than will a continual bombardment of questions. The teacher needs to consider the quality of the questions as well as the quantity included in the lesson.

Stevens, in her study, suggested that the teacher should preplan six to eight thought-provoking questions to use as a part of the lesson (Stevens, p.84). This, again, is a generalization rather than a rule to be rigidly followed. Preplanning is important, but a teacher should be well prepared with respect to content and flexible enough to modify or abandon the set of preplanned questions if circumstances develop, during the lesson, which appear to be more favorable in promoting the discussion than what the teacher had decided upon the night before or whenever the preplanning was done.

The teacher's questions perform a variety of teaching functions. They may stimulate the discovery of new ideas or the performance of certain thinking operations. "Open questions" suggest the thinking operation the student is to perform but not what the student may think or say. "Open questions" may be used to set the focus of the lesson. The use of "open questions" should, hopefully, encourage students to become increasingly more independent in processing information and less dependent on the teacher for support and for final authority. Because "open questions" permit many alternative answers, students should become less likely to form the habits of trying to guess what response the teacher wants to hear or to recall information given in the textbook and not going beyond this recalled information.

"Open questions" may be used to stimulate interest, arouse motivation for further study, or to develop insights, appreciations or attitudes. They may be used when the teacher is introducing a new idea or topic. They may also be used when the teacher thinks that enough background information has been acquired and that the class is ready to use this information to synthesize or to engage in other divergent thinking activities.

Evaluative thinking operations are also used when the teacher asks the students to propose hypotheses to explain a situation or to propose possible experimental designs (to state two examples), because of the implication that the students will be called upon to justify their procedures.

It is, however, unrealistic to think that teachers can stress the use of "open questions" to the exclusion of "closed questions." Students have to acquire information which they can use in their thinking operations. The distressing fact is that many teachers operate as though their function was limited to helping the students acquire the information and that some other individual would cause the students to use it at a later time.

"Closed questions" play a part in concept formation in that concepts are formed as students respond to questions which require them to (1) enumerate items; (2) find a basis for grouping items that are similar in some respect; (3) identify the common characteristics of items in a group; (4) label the groups; and (5) subsume items that they have enumerated under those labels (Taba, p.92). Each of these steps is a necessary prerequisite for the next one. This implies that the teacher must develop the skill of asking sequentially ordered questions. The teacher should ask the questions, but the students should perform the thinking operations. The use of "closed questions" does not imply that the students should develop a supply of acceptable responses that they produce automatically when the teacher says the magic word.

Teachers should learn to adapt their questioning techniques to the purposes of the teaching situation as well as to the background, level of maturity, and fund of experiences of the students with whom they are interacting. They need to structure their questioning so that it counterbalances the previous years of conditioning against going beyond what was given on the printed page or what the teacher said. Teachers should be aware of the fact that their questions serve not only to emphasize the content about which the students are to think but also the thinking operation to be performed on the content. (The diagram on the following page is an attempt to present this idea in model form.)

Some Additional Remarks about Handling Student Responses

The way in which a teacher handles pupil responses and questions is important. When a teacher questions a pupil or solicits information (i.e. Name three examples of igneous rock. Describe the structure of a typical plant cell. What is your opinion on this matter? How could you test the validity of this?), the pupil may or may not respond. If he responds, he may attempt to answer or he may also ask a question or interject a comment. If he attempts to answer, the student's response may be correct, incorrect, or correct but inadequate. A correct but inadequate response may be described as being one in which the student gives one or two reasons when the teacher desires three or four.

The following point deserves emphasis: It is difficult to specify how a teacher should handle a student response. The teacher's actions are related to (1) the teacher's purposes in questioning, (2) the nature of the student response, (3) the nature of the student responding, and (4) the classroom context.

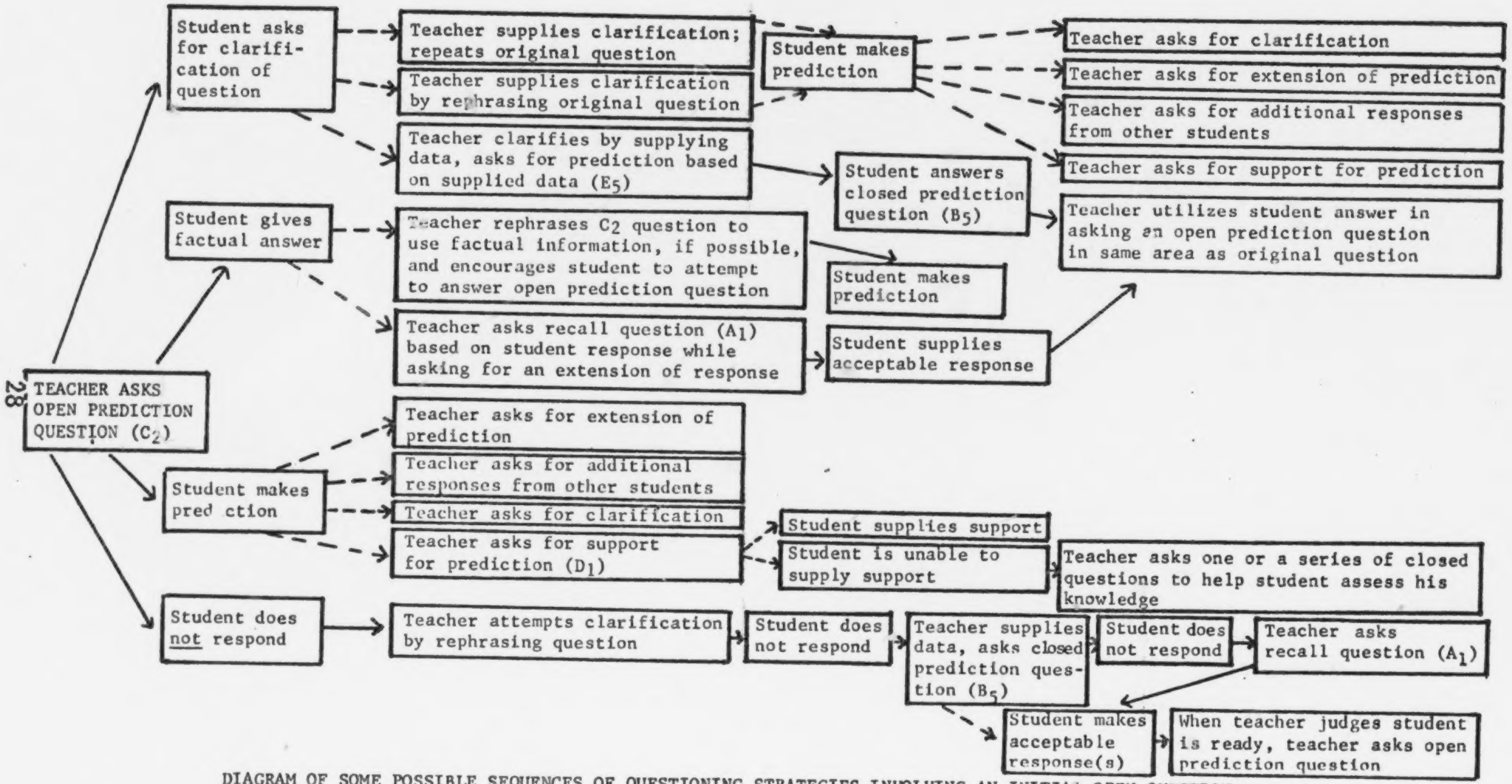
TEACHER ASKS OPEN PREDICTION QUESTION (C2)
Student asks for clarification of question
Teacher supplies clarification; repeats original question
Teacher supplies clarification by rephrasing original question
Teacher clarifies by supplying data, asks for prediction based on supplied data (E5)
Student makes prediction
Teacher asks for clarification
Teacher asks for extension of prediction
Teacher asks for additional responses from other students
Teacher asks for support for prediction
Student answers closed prediction question (B5)
Teacher utilizes student answer in asking an open prediction question in same area as original question
Student gives factual answer
Teacher rephrases C2 question to use factual information, if possible, and encourages student to attempt to answer open prediction question
Student makes prediction
Teacher asks recall question (A1) based on student response while asking for an extension of response
Student supplies acceptable response
Student makes prediction
Teacher asks for extension of prediction
Teacher asks for additional responses from other students
Teacher asks for clarification
Teacher asks for support for prediction (D1)
Student supplies support
Student is unable to supply support
Teacher asks one or a series of closed questions to help student assess his knowledge
Student does not respond
Teacher attempts clarification by rephrasing question
Student does not respond
Teacher supplies data, asks closed prediction question (B5)
Student does not respond
Teacher asks recall question (A1)
Student makes acceptable response(s)
When teacher judges student is ready, teacher asks open prediction question

DIAGRAM OF SOME POSSIBLE SEQUENCES OF QUESTIONING STRATEGIES INVOLVING AN INITIAL OPEN QUESTION

If the response meshes with the teacher's purposes in questioning, the teacher may accept the response in a positive manner or accept it in a neutral manner (with no reinforcement) and proceed. In general, the classroom climate is better if the teacher's response and/or appraisal are positive. The teacher may, in some situations, reflect the response to the class for further comment by other students. He may accept the response and add some clarifying remarks or extend what the pupil has said. Other possible patterns exist. It is hoped that the patterns followed will be those which result in a decreased amount of teacher talk.

Most teachers ask "closed questions" with the idea of receiving the desired response. If the pupil's response is incorrect (not what the teacher desired) or correct but inadequate, a new series of teaching moves must be initiated rather than those predicated upon receiving the desired (or "correct") response. In general, the teacher should react to an incorrect or inadequate pupil response in such a manner that the pupil does not feel he is being punished for his response. Punishment does not necessarily eliminate undesirable pupil behavior. It may, however, cause a student to refrain from participating in class discussions or volunteering answers. The teacher must find a method for telling the pupil he is wrong while keeping him interested in the discussion. The teacher needs to become sensitive to the effects of correction on each pupil.

This should not be interpreted to mean that a teacher must never be critical or make judgmental statements about the correctness or adequacy of the response the pupil has made. Some pupils accept moderate, thoughtful criticism as a challenge and consider it indicative of the teacher's interest in them. Others interpret any remark with negative connotations as rejecting them as individuals along with their answers. This is another aspect of teaching that involves insight into individuals and their reactions. Such insight develops slowly, for most individuals, and is not an automatic byproduct of courses in educational psychology or the student teaching experience.

When the teacher tells the student his response was incorrect or inadequate, he should provide an opportunity for the student to give a correct response. The teacher's reaction should be worded in such a way that the pupil is encouraged to try again. Again, there are no patterns or strategies which will guarantee success each time they are used. Different tactics work for different teachers and with different students. The particular procedure that is used cannot be readily determined apart from the context of the classroom situation in which the interaction occurs.

In some instances, the teacher may handle the situation by avoiding any negative comments at all. If the student has had a history of failure in the classroom, the first problem that must be solved is getting him to respond at all. With students of this background, the teacher may not give any value statement regarding the pupil's answer and may work with them to arrive at a more desirable answer (Minicourse One, pp.27-33). Again, this assumes that you as the teacher know the backgrounds and history of failures and/or successes of your students. This is not always easily accomplished in the student teaching experience. Nevertheless, student teachers do learn the characteristics of their class or classes, sometimes through their encounters with the pupils and frequently from the estimate of the average class ability made by the cooperating teacher.

The teacher can react with such statements as "Can you think of anything you could add to improve your answer?" or "I am going to let you have a little more time to think about that and come back to you in a few minutes." It does no good to verbally prod and probe a student when he is unable to produce the responses the teacher desires. The teacher may reinforce the part of the answer he considers acceptable and then turn to other pupils for additional information, e.g. "What might be added to her answer if we wanted to improve on it?" Or, the teacher may continue to question the student, using a different question aimed at a less complex level of thinking. In this way the teacher attempts to lead the student to the response the teacher had originally hoped to hear. Groisser, in How to Use the Fine Art of Questioning, presents a lengthy example of such an episode. Such Socratic dialogue is not always possible or desirable in a large class situation, but it can be done on a one-to-one basis if this can be arranged and the teacher is skillful in posing questions.

Frequently the pupil's response to a teacher's question will be in the form of a question. Student questions may take the form of requesting information, clarification, or amplification. They may also be questions stimulated by the question the teacher posed. Students should be encouraged to ask questions on points not clear to them. A teacher must however, learn to distinguish between genuine interest and a need for help and efforts to sidetrack the discussion along unprofitable paths. Knowledge of individual students is an important factor in such situations.

If a teacher's question receives a student question in return, the teacher has a number of alternative strategies from which to choose. He may, as is frequently the case, ignore the student's question and proceed with his own questioning. The teacher may clarify the question he posed or he may ask another student to do this. He may accept the student's question in a neutral manner, a positive manner, or a negative manner. The teacher may reflect the student's question to its originator or he may direct it to the class in general or to a specific student. He may ask the student to clarify the question he asked. The teacher may word his response in such a way that he is asking the student to justify the appropriateness of his question at this point in the discussion. The strategy the teacher chooses to use should be based on his considered judgment of what will best serve the needs of the individual student who posed the question and the needs of the rest of the pupils in the class.

The teacher needs to respond with tact, courtesy and firmness and to set standards which he expects his students to follow. The teacher should not attempt to answer all questions he considers legitimate or pertinent. Students should be encouraged to answer their own questions or to discuss their questions with the rest of the class. The teacher should provide the answer when the information the student seeks to learn is known only by the teacher or when getting the answer would require an inordinate amount of effort on the part of the student (Odell, p.4).

The teacher should help the students learn to distinguish between significant questions and irrelevant questions, as well as between answers based on fact, logic and reason and answers based on opinion. Students should be encouraged to ask questions freely and to question the authority of a statement.

Even though the terms "correct" and "incorrect" have been used with a minimum of qualification in the discussion of handling student responses, this terminology could be argued. There is a frequently-heard statement to the effect that answers in the sciences cannot be said to be "correct" (or "incorrect") but can only be said to be closer approximations of the truth. Both students and teachers frequently act as if the teacher were the unquestioned authority in the classroom. Such an acceptance of teacher direction and authority in the classroom would appear to be contrary to the spirit of inquiry, open-mindedness, and independent critical thinking that is commonly considered to be one of the more desirable outcomes of science teaching.

If the teacher is using questioning techniques to aid in the development of critical thinking on the part of the student, he should remember that learning by authority primarily stimulates such thinking activities as recognition, memory, and logical reasoning. It is to be hoped that questioning techniques and strategies will go beyond these levels to activities of divergent thinking and evaluation.

Some concluding generalizations

Teachers should recognize that questioning is only one of many effective teaching techniques. Questioning or questioning techniques are a means to an end, not an end in themselves. They are useful only if they serve the teacher's purposes in facilitating the learning of the students in his class.

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Rivlin, H. N. Teaching Adolescents in Secondary Schools. New York: Appleton-Century-Crofts, Inc., 1948, Ch. 7, pp. 190-235.
This chapter combines both theory and practice in its treatment of questions.

Sanders, Morris Classroom Questions: What Kinds. New York: Harper & Row, 1966.
A paperback book again designed for social studies teachers in which the author has based his classification of questions on a modified version of Bloom's Taxonomy. The self-testing exercises at the end of each chapter are excellent for deciding if you really understood what you read and can apply it.

Schorling, Raleigh Student Teaching. New York: McGraw-Hill Book Co., Inc., 1949, Ch. 9, pp. 228-244.
Another source from which to choose if you want more information on improving questioning than is contained in this handbook.

Simon, Anita and Boyer, E. G. eds. Mirrors for Behavior. Philadelphia: Research for Better Schools, Inc., 1967.
A collection of classroom interaction analysis systems, designed to provide you with background information but not with suggestions on what to use or how to use it, if you want to analyze classroom interaction.

Stevens, Romiett The Question as a Measure of Efficiency in Instruction. New York: Teachers College, Columbia University, 1912.
What she found for her dissertation, in 1912, still--unfortunately-- holds true today in most classrooms.

Suchman, J. R. Developing Inquiry. Chicago: Science Research Associates, 1966.
An explanation of Suchman's program designed to develop students who are independent inquirers.

Taba, Hilda Teachers' Handbook for Elementary Social Studies. Palo Alto, California: Addison-Wesley Publishing Company, 1967.
Another publication by the social studies people from which science teachers can benefit. The information on cognitive maps and concept formation is applicable to any subject field.

Teacher Education Program Staff Minicourse One: Effective Questioning in a Classroom Discussion. Berkeley: Far West Laboratory for Educational Research and Development, 1968.
Part of the package designed for use by inservice teachers of the intermediate grades as a self-instructional device for improving their questioning skills.

Verduin, J. R. Jr., ed. Conceptual Models in Teacher Education. Washington, D.C.: American Association of Colleges of Teacher Education, 1967.
A relatively sophisticated discussion by a number of "authorities" in various fields concerning the improvement of undergraduate teacher education programs and the importance of questioning as a teaching technique.

Wrinkle, Wm. L. and Armentrout, W. D. Directed Observation and Teaching in Secondary Schools. New York: The Macmillan Co., 1935, Ch. 8, pp. 184-204.
Another source of information about the improvement of questions and questioning.

Yoakam, G. A. and Simpson, R. G. An Introduction to Teaching and Learning. New York: The Macmillan Co., 1934, Ch. 5, pp. 105-123.
See annotation directly above.

APPENDIX A

This appendix contains some additional information relative to methods of increasing pupil verbal participation in a class discussion.

I. Five Ways of Getting Pupils to Go Beyond Superficial First Answers

(from: "Technical Skills of Teaching," in Micro-teaching: A Description, Stanford University, Stanford Teacher Education Program, 1967, p.5)

(1) Ask pupils for more information and/or more meaning.

(2) Require the pupil to rationally justify his response.

(3) Refocus the pupil's or class's attention on a related issue.

(4) Prompt the pupil or give him hints.

(5) Bring other students into the discussion by getting them to respond to the first student's answer.

II. Probing Techniques: "probing" is used to mean some technique aimed at getting a student to go beyond a superficial or inadequate first response. (from: McDonald, F. J. and Allen, D. W. Training Effects of Feedback and Modeling Procedures on Teaching Performance, Stanford: School of Education, 1967, pp. 189-191.)

Examples of questions that might be used in getting a pupil to amplify his initial response:

(1) Seeking further clarification:
What do you mean?
Please rephrase (or, clarify) what you mean.
Can you explain that further?
What do you mean by the term _______?

(2) Seeking increased pupil critical awareness or rational justification of the response:
What are you (or, we) assuming here?
Why do you think this is so?
Have you (or, we) oversimplified the issue. . . is there more to it?
Is this one or several questions?
How would someone who took the opposite point of view respond to this?

(3) Seeking to refocus a good answer:
Good! What are the implications of this for ...?
How does this relate to ...?
Can you take it from there and tie it into ...?

(4) Prompting the pupil who needs help:
T: John, will you define the term polygenesis?
P: I can't do it.
T: What does poly mean? (Or, Genesis means origin or birth, and poly means . . .?)

(5) Seeking to redirect the interaction and bring other students into the discussion:
T: What is the relationship between pressure and volume?
1st P: As pressure goes up, the gas is condensed.
T (to 2nd P): Can you explain what is meant by "condensed"? Or Can you restate that in terms of volume?

All five techniques have two things in common:

(1) They are initiated immediately after the pupil has responded.

(2) They require the pupil to go beyond the information he has already given.

Don't forget to reinforce when you "probe"--otherwise, it may get to sound as if the pupils were on trial. It should be a classroom learning situation, not a court of law.

APPENDIX B
EXAMPLES OF QUESTIONS

The following pages contain some examples of the various kinds of questions that might be classified under the different thinking operations listed in the Question Category System give on page 12 of the handbook.

It is difficult to take a question out of the context of the planned lesson and classroom discussion and arbitrarily write it out as an example of a particular thinking operation. Some of the examples cited might be categorized under different thinking operations if they were used in a different context. These questions are given to be used as general guides in learning to distinguish the place in the Question Category System into which a given question might be classified.

It might be a good idea to attempt to write several questions of your own for each thinking operation listed in the Question Category System. Or, you might list all of the questions you could possibly ask in developing a specific lesson or topic and then classify each to see how many different thinking operations you are attempting to stimulate in your students.

EXAMPLES OF QUESTIONS RELATING TO DIFFERENT TYPES OF THINKING OPERATIONS

A. COGNITIVE-MEMORY QUESTIONS (evidence for answer directly available in some form)

1. RECALL: student is asked to remember and present information previously learned. This may include asking student to repeat or restate a response made earlier in the discussion. Student may also be asked to perform some manual operation that has been explained or to duplicate it as specified in the directions.

   "What is the function of the blood?"
   "What is the definition of osmosis?"
   "What did you tell us a few minutes ago about that?"
   "What is the proper way to focus a microscope?"

2. IDENTIFY, NAME, OBSERVE: student is asked to identify an object by naming it, pointing to it, selecting it out of a group; to state what he observed without drawing any inferences, conclusions, etc.

   "Which flask shown in the picture is the Florence flask?"
   "Give me an example of an igneous rock."
   "When the copper was heated, what color was the flame?"
   "How many different cell layers do you see on that slide?"

B. CONVERGENT THINKING QUESTIONS (evidence for response directly available but not in form called for by question)

1. ASSOCIATE, DISCRIMINATE, CLASSIFY: student is asked to focus on likenesses or similarities; to equate; or student is asked to compare or contrast, to focus on differences. CLASSIFY (criteria given) is also placed in this category since it involves association and discrimination. Student is given a set of criteria or helped to develop a set and then use this in classifying objects.

   "Why are sandstone, limestone and conglomerate all classed as sedimentary rocks?"
   "What are some common properties of plants and animals?"
   "What're the major differences between DNA and RNA--they're both nucleic acids?"
   "How can you distinguish gneiss from schist?"
   "Limestone and sandstone are both sedimentary rocks. How can you tell them apart?"
   "Group the materials listed on the board as elements, compounds, or mixtures."

2. REFORMULATE: student is asked to give the answer in his own words, not those of the textbook or teacher; to interpret verbal data into graphical form or vice versa; to paraphrase an important idea.

   "What is your version of the results shown in the chart on page 45?"
   "Can you tell us, in your own words, what these data mean?"

3. APPLY: student is asked to use previously acquired data in stating the possible causes of a phenomenon, the reasons for a particular procedure or process--providing this goes beyond a memorized definition available in the textbook or previous lesson material (if this is all that is involved the question is a "recall" one). Student may also be asked to use previously acquired knowledge in solving a similar but unfamiliar problem; to cite examples to illustrate a particular phenomenon or process other than those already discussed; or student is given a value, skill or definition and asked to identify or compose an example of its use.

3. APPLY (continued)

   ". . . and this process is called osmosis. Where might osmosis take place in our bodies?"
   "What happened to the air inside the balloon, in terms of molecular motion, when the flask was heated?"
   "What caused the limestone to effervesce when acid was dropped on it?"
   "Based on what you have just said about the process of convection, what part do you think convection currents play in the heating and cooling of houses?"

4. SYNTHESIZE: student is asked to combine pieces of information to form a whole, to make generalizations.

   "If the air temperature in a room is 85°F and the wall temperature is 50°F, why might a person feel cold?"
   "Explain why it is or is not correct to say that matter is not destroyed when a piece of wood is burned."
   "What generalizations can you make from the data you gathered?"

5. CLOSED PREDICTION: student is asked to form a prediction, using data which limits his answer.

   "On the basis of the results we collected in this class, how do you think arm lengths would vary if we were to use younger students in our sample?"
   "If both parents were hybrids, what would you expect the F_1 generation to look like?"

6. MAKE "CRITICAL" JUDGMENT: student is asked to form a restrictive judgment about the correctness, adequacy, appropriateness, etc. of some situation or response, using standards or criteria that are commonly known by the class.

   "Does anyone wish to challenge that answer?"
   "How do the relative sizes of these objects compare?"
   "Is that the proper procedure to use?"

C. DIVERGENT THINKING QUESTIONS (evidence for response not directly available)

1. GIVE OPINION: student is asked for his opinion without also being asked to justify it or to present a rationale for his response. These differ from the "make 'critical' judgment" variety in that the context in which the question is asked is such that there is no implication that only a limited number of responses will be considered acceptable by the teacher.

1. GIVE OPINION (continued)

"Do you think we should repeat this experiment?"
"What do you think?"
"Do you think the results we got would be changed much if we were to increase the temperature two degrees?"

2. OPEN PREDICTION: student is asked to make a prediction but the data available are insufficient to limit the response expected, students are asked to speculate, to "brain-storm."

"If we were to land a spaceship on Venus and, if Venus were to be inhabited, what might the welcoming committee look like?"
"What do you think might happen if the Sun were to 'die'?"
"What do you think life on Earth will be like 200 years from now?"

3. INFER or IMPLY: student is asked to draw inferences or to point out implications.

"What can you infer, from the evidence you collected in your experiment, about the growth curve of those bacteria?"
"What inferences can you make based on the data you collected?"
"What are the implications of that conclusion?"

D. EVALUATIVE THINKING QUESTIONS (evidence for response may or may not be directly available; criteria for responding are available, either directly or indirectly. Implication is that student may be called upon to provide a defense for his response.)

1. JUSTIFY: student is asked to elaborate on the reasons for his response; to defend his position on some rational grounds; to develop a rationale for his actions.

"Why did you use litmus paper rather than hydrion paper?"
"Upon what basis did you form this conclusion?"

2. DESIGN: student is asked to design or formulate a new method of doing something, to establish a testable hypothesis, etc.

"Can you think of a different way of solving this problem?"
"Can suggest a design for an experiment to investigate that?"

3. JUDGE A: student is asked to judge some situation involving a matter of value or worth, with the implication that the thing being judged relates to himself or other persons, hence the involvement of affective behavior.

3. JUDGE A (continued)

> "Should we set up a policy whereby human organs are automatically made available for transplant operations when a person dies?"
> "How would you handle this situation?"

4. JUDGE B: student is asked to judge some situation in which the judgment is to be made on the basis of utility, consistency, logical accuracy or other cognitive standard.

> "Which process should we use if we wish to solve the problem in the most efficient manner?"
> "Is the conclusion you reached based on valid evidence?"

APPENDIX C
TEACHING FUNCTIONS OF CLASSROOM QUESTIONS

Teachers use questions to stimulate thinking. They also use questions to structure and control classroom discussions. The following is a brief explanation of eight teaching functions that questions may serve while they also call for a particular thinking operation:

(1) Setting the focus of the discussion. Such questions establish the topic to be discussed as well as the particular thinking operation to be performed. Focusing questions may be either "open" or "closed," depending on the teacher's objectives for the lesson.

(2) Refocusing the trend of the discussion. If the class has wandered from the original topic or changed the focus so that the teacher anticipates that the discussion will not proceed as planned, he may need to use a refocusing question to reestablish the sequence of thought.

(3) Changing the focus of the discussion. Such questions may serve to change the focus or to extend the topic being discussed. For example, after the students have listed the various rock-forming minerals, the teacher may ask them to identify some igneous, sedimentary or metamorphic rocks composed of these minerals.

Once the focus of the discussion has been established and the thinking operations have been identified by the students as well as by the teacher, the teacher may use subsequent questions to extend the thought and discussion at this same level or to lift the thinking to a higher level. If the teacher decided that the discussion and thinking operations should continue for a time at the level first established by the original focusing question, he will need to ask and/or use student questions that call for elaboration or clarification and which serve to extend the discussion without changing the level of thinking.

(4) Clarifying the discussion. The teacher may ask the student to specify meaning or to give an example. Clarifying questions are useful if the teacher wishes a student to restate an abstract answer in more concrete form or if the teacher suspects that a highly verbal student has presented an appropriate answer which he really does not fully understand. Frequently teachers equate comprehension with the use of appropriate terminology. This assumption is not always justified.

(5) Offering support to a student. Such a function lies more in the affective domain than in the cognitive. For example, if a student makes an error, the teacher may give him an opportunity to correct it by asking him to clarify what he said. The clarification question may not achieve its intended purpose of having the student correct his error. The teacher may then ask if any other student has a different idea. In both instances, the teacher refrains from correcting the student. Hopefully, such treatment will support the student and encourage him to continue to participate in the discussion.

(6) Broadening patterns of thinking. Teachers can ask questions based on specific facts that cause the students to make generalizations in their attempts to respond. The teacher may ask a student to summarize the discussion and to integrate the information into a consistent pattern of thought.

(7) Initiating exploration of new dimensions of a topic. In order for questions to serve this function, the teacher must be familiar with the important dimensions of the topic. Then the teacher can use his knowledge to assess the student responses and to decide which ones to use in the development of the topic.

If the teacher wishes to move the thinking and discussion of the class to a higher level, he will use one of several teaching functions: (3), (6) or (7). He will, however, need to structure his questions so that the students are able to follow the transition. He should be certain that his students have an adequate amount of descriptive information before he asks them to generalize or to make inferences or identify implications. For example, if he wants his students to interpret data, he needs to ask questions that will result in information which students can use when they are asked to carry out the interpreting operation.

Pacing is important here. If the teacher tries to proceed too rapidly for the majority of the students to follow, he will find that fewer and fewer students are participating in the discussion and/or that the trend of the discussion is toward the level of information-giving rather than that of high level thinking. He needs to spend sufficient time at the level of seeking descriptive information before he proceeds to ask for explanations. After students have spent time in providing and/or evaluating explanations, they become ready to attempt to generalize, but not before. A teacher who attempts to go from specifying of information to generalizing, omitting the activity of explaining, or the teacher who spends less time at each level than the majority of his students require to function adequately in their thinking will recognize that his pacing and sequencing of activities were poorly planned as the discussion falters and rambles and fewer and fewer students participate.

(8) Recapping the discussion. A recapitulation is considered to be more all-encompassing than a summary. It serves to lift out ideas in order to make them more understandable to the class and to provide a clearer perspective. Recap questions should elicit answers that enable the students to see relationships more clearly and to advance their thinking to more general ideas and conclusions.

Material in this appendix was adapted from Taba's Handbook, pp. 79-86.

APPENDIX D
SUGGESTIONS FOR MATERIALS TO USE IN PLANNING "OPEN QUESTIONS"

"Open questions" are defined as those for which there is a relatively wide range of responses considered acceptable. These "open questions" also include ones for which scientists do not yet have acceptable answers. Because these questions do not limit what the students should think or say in their responses, the asking of such questions implies that they are used for particular purposes or with particular types of materials or topics. You would not, for example, plan to use "open questions" when you were focusing on review of material or when you were attempting to reinforce some material the class had just encountered. "Open questions" might, however, be used when introducing a new topic--to stimulate interest or to provide motivation for further study.

When asking "open questions," you should not depend on a particular body of background information. The students may or may not possess it. Then, too, such a dependence tends to result in recall questions rather then those which stimulate divergent or evaluative thinking.

Developing "open questions" is not an easy task. Perhaps this is the reason teachers seldom ask them or do not ask them as frequently as they ask "closed questions." In order to provide you with some help in preparing for demonstrating the skill of asking "open questions" in a micro-teaching lesson, the following list of materials and topics that may lend themselves to this activity is included:

graphs, tables, charts
slides (Kodachrome, 2x2 type)
inquiry films such as those of Suchman
brief domonstrations (5-10 minutes)*
brief experiments (5-10 minutes)*
transparencies with overlays
some ESCP experiments
"Invitations to Enquiry" in Biology Teachers' Handbook by Schwab
topics or concepts such as--
  evolution, the particle nature of matter, continental drift, the age of the Earth, the origin of life, the origin of the solar system, etc.
some of the materials related to the Physical Science for Nonscientists course of study.

(* not including time to assemble and set up the equipment)

Two points of caution: the use of materials or topics such as those listed on the preceding page is no "sure-fire" guarantee that the questions you develop will be of the "open" type. Presenting data to your students in the form of a chart, graph or table and then asking them to interpret the data may result only in convergent thinking if the questions you use cause the students to explain, apply, predict within limitations, etc. Some of the "Invitations to Enquiry" are structured so that if you rely only on the questions included in the book, only convergent thinking operations will be stimulated.

Secondly, if you do not directly or indirectly stress the point that you want the students to formulate their own answers rather than attempting to guess what you would like to have them say, you may get very little student participation in the discussion. The use of pausing behavior is important here. Asking an "open question" involves allowing the students time to think before they respond. Frequently teachers ask well formulated "open questions" and when they do not receive an almost-immediate response from a student, they either answer the question themselves or reformulate it into one or more convergent thinking questions. Be willing to wait for thinking to take place!

Another point that should be mentioned is that it is possible to ask "open questions" in the context of a science lesson. Asking "open questions" does not mean that the lesson has to evolve into idle chit-chat or that it has to center around topics only remotely related to science content and materials.